An investigation of the fluency paradigm:

The effects of accuracy training before rate-building and incremental increases in responses rates on skill retention, endurance, stability, application and adduction

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(B.Ed.Hons.)

This thesis is presented for the degree of Doctor of Philosophy in Education at Murdoch University, 2004.

I declare that this dissertation is my own account of my research and contains as its main content work which has not been previously submitted for a degree at any tertiary institution.

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ABSTRACT

Fluency has recently been operationalized in terms of the acquisition of performance rates that predict a number of learning outcomes, depicted in the acronym RESAA, which represents skill retention, endurance, stability, application and adduction (Johnson & Layng, 1996). The RESAA model has not yet been adequately researched under controlled, experimental conditions.

A preliminary study (Study 1) compared two rate-building procedures, under experimental conditions, with five Year 2 children with a mean age of six years eight months and seven pre-primary children with a mean age of four years seven months. The effects of practice and reinforcement were controlled. Long-term follow-up RESAA measures were conducted three months after the completion of the intervention.

The major study in this research project (Study 2) is an empirical investigation of the effects on RESAA measures of increasing the performance rates of a component skill in reading to specific, incremental rate aims with twelve Year 2 children aged between six years eight months and eight years one month who were categorized into three levels of reading ability. Speeded practice was compared to slow-paced constrained-rate practice. The effects of practice and reinforcement were controlled. The utility of learning channel analysis for defining measures of application and adduction, and for measuring adduction on two composite tasks involving topographically dissimilar sensory and response dimensions was examined. Long-term follow-up RESAA measures were conducted three months after the completion of the intervention.

The results of Study 1 indicated a procedure in which accuracy and rate were trained simultaneously was more efficient in increasing component skill rates and produced higher rates on the RESAA measures than training accuracy to 100% in a stage before rate-building commenced for the Year 2 children and two pre-primary children. Training accuracy to 100% before rate-building was marginally more efficient for five of the pre-primary children. Adduction was greater for a one learning-channel cross than for a two learning-channel cross.

The results of Study 2 demonstrated that systematic increases in component skill rates were produced by both the rate-building and constrained-rate procedures, although higher rates were produced by the rate-building procedures for eleven of the twelve children. Higher training rates of the component skills produced concurrently higher rates on repeated RESAA measures during the intervention and on RESAA follow-up measures. Adduction was greater for a two learning-channel cross than for a one learning-channel cross. The level of reading ability of the children did not influence training rates of the component skill but did affect performances on the RESAA measures. Comparisons indicated that different training rates predicted different RESAA outcomes for all of the children.

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CHAPTER 1

INTRODUCTION

The DSM-IV states that up to 10% of the population are affected by learning disorders (Rappaport & Ismond, 1996). Leach (1996, p. 3) reported that the Australian House of Representatives Enquiry (1993) showed that between 10% and 25% of children in Australia "have significant difficulty mastering such skills [basic educational skills] in order to become independent in their use". Leach (1996) also referred to a study by Prior, Sanson, Smart, and Oberklaid (1995) that found 16% of children in Victoria have been described as reading disabled. These figures demonstrate the need for effective teaching techniques that prevent academic failure of this magnitude.

Rate-based practice procedures have been identified by researchers as highly powerful techniques in remediating learning and attentional problems in school-aged children (Johnson & Layng, 1992; 1994; 1996; Binder, 1996). Since the 1970's Precision Teaching (PT) programs, of which rate-building is an integral element, have consistently produced impressive results in a range of settings, with different populations and for a number of academic and non-academic skills (Lindsley, 1992a; 1992b; Doughty et al., 2004). Precision Teaching is a method of teaching that bases instructional decisions on changes that occur in continuous monitored student performance frequencies, or rates, that are displayed on charts called "standard celeration charts" (Lindsley, 1992b). Despite their demonstrated success, rate-based procedures and measurement in education have not gained widespread adoption in schools (Binder & Watkins, 1989; Binder, 1990a; Lindsley, 1992a; Worthy & Broaddus, 2002; Chard, Vaughn, & Tyler, 2002). A major reason for the non-implementation of such effective teaching tools in most contemporary classrooms is the limited dissemination of PT and rate-building training procedures and achievements (Binder, 1990a; 1996). Secondly, although a wealth of anecdotal evidence supports the effectiveness of rate-building techniques in education, there needs to be more controlled empirical research into the specific effects of such instructional procedures on learning outcomes (Doughty, Chase & O'Shields, 2004; Binder, 1996) and guidelines for practitioners remain in parts unclear or empirically unsubstantiated.

Many researchers and educational practitioners have emphasized "fluent performance" as a critical component in reading success (Carnine, Silbert & Kameenui, 1997; Lipson & Lang, 1991; Mounsteven, 1990; Meyer & Felton, 1999; Freeman & Haughton, 1993; Stanovich, 1980; Samuels, Schermer, & Reinking, 1992; Rasinski, 1989). However, there is no consistency in the literature concerning the definition of fluent reading and how fluent rates should be measured and determined, although most authors agree fluent reading performance is related to adequate reading speeds (Perfetti, 1986; Rasinski, 1989; White & Brewer, 1992; Johnson & Layng, 1996; Worthy & Broaddus, 2002; Lipson & Lang, 1991).

Further research into rate-building procedures to increase response speeds, and their relationship to subsequent learning, has been advocated by many researchers to allow a shift from the largely metaphorical use of the term "fluency" to a behavioural and functional definition of fluent performance (Johnson & Layng, 1996; Binder, 1996; Lindsley, 1992b). The pursuit for an operational definition of fluency and its direct role in learning has been in progress since the 1980's (Lindsley, 1996a). Reviews of the related literature revealed many unanswered questions and promising hypotheses that required empirical validation. The purpose of the current research project was to address some of these important questions and to experimentally examine some of the proposed hypotheses surrounding rate-building and the concept of fluency in an attempt to more clearly define the parameters of fluent performance and its relationship to subsequent learning.

A brief introduction to the current research is presented in this chapter. The relevant concepts pertaining to the procedures and measures employed are introduced and briefly defined. In the next chapter each concept is described in more detail and elaborated through a review of the related literature. The results of the research are discussed from a predominantly behavioural perspective in later chapters. The concepts and theoretical models that relate to these discussions are also established and briefly defined in this chapter. A common problem in the rate-building literature is a lack of consistency in the use of terms relating to fluent performance, and this has coincided with repeated misunderstandings associated with the conceptualization of fluency. Therefore, the terminology used in this thesis is stated in this chapter, although the inconsistencies in the use of terms are highlighted and discussed in the literature review in Chapter 2.

The research investigates the paradigm of fluent performance. *Fluent performance* refers to proficient behaviour that is characterised by the smooth and effortless combination of accuracy and speed (Binder, 1996). The instructional procedures involve *rate-building* exercises which aim to increase response rates. *Response rates* are used to measure speeds of performance and are expressed as the number of movements or behavioural events per unit of time, which is usually one minute (Kunzelmann, Cohen, Hulten, Martin, & Mingo, 1970; Williams, Haring, White, Rudsit, & Cohen, 1990; Fuchs, Fuchs, & Tindal, 1986; Valleley & Shriver, 2002). *Correct response rates* are defined as the number of correct responses per minute.

Incorrect rates are counts of the number of incorrect responses per minute. Response rates are increased to specific rate aims. *Rate aims* depict target performance rates that are expressed as specific ranges of response rates. In this research, all rates are expressed as the number of correct phonemes per minute (*ppm*). For example, a rate aim of 0-20 ppm would indicate performance of correct responding between 0 ppm and 20 ppm. The term “rate criteria” is often used interchangeably with the term “rate aims” in rate-building literature, and these terms appear in the literature review of this thesis when describing specific studies. Within the context of this research project the term “rate aims” is used, as the focus of the investigation was the measurement of the effects of attaining particular target speeds of responding on learning outcomes, rather than <u>setting</u> specific rate criteria that optimize these outcomes.

The effects of the achievement of specific rate aims were assessed on a set of retention, endurance, stability, application and adduction measures. The definitions provided by Johnson & Layng (1996) were employed in the current research. *Retention* refers to the performance of the trained skill at the rate aim after a significant period of no practice. *Endurance* describes the performance of the trained skill at the rate aim over a longer timing period than used during training. *Stability* depicts the performance of the skill at the rate aim in the presence of distraction. *Application* refers to the demonstration of the trained skill as a component of a higher-level composite skill. *Adduction* describes the performance of the trained skill in combination with other component skills to form novel, previously untaught behaviours. These learning outcomes form a set of measures termed <u>RESAA</u> criteria or performance standards (Johnson & Layng, 1996). An important clarification relating to the RESAA criteria is required and was noted by Binder (2004). The use of the term “learning outcomes” is not intended to suggest that “fluent performance” is an attainable outcome in itself that then produces retention, endurance, stability, application and adduction. Rather, the RESAA criteria represent a set of learning outcomes or standards that are characteristic of functional fluent performance and that occur when response rates are built to sufficient speeds. This conceptualization in relation to Binder’s (2004) comments is described in more detail in the following chapter.

The interventions target sound-symbol correspondences. In Study 1 the pre-primary children learned phonemes for individual letters of the alphabet. *Phonemes* are separate speech sounds and are basic units in speech (Emmitt & Pollock, 1994). The Year 2 children in Study 1 and all of the children in Study 2 were trained to read phonemes represented by digraphs. *Digraphs* are two letters that represent a single sound or phoneme (Emmitt & Pollock, 1994).

The skills targeted for intervention are component reading skills. *Component skills* are the most fundamental elements of more complex skills (Koorland, Keel, & Ueberhorst, 1990; Johnson & Layng, 1992). The effects of training these component skills to successively higher training rates were assessed on each of the RESAA measures. The application and adduction measures involve the performance of the target skills on composite skill tasks. *Composite skills* are more complex, higher-level skills of which the components are a part (Johnson & Layng, 1992; Binder 1993).

The learning tasks and responses of the participants are described in terms of learning channels. *Learning channels* are descriptions of the sensory dimensions by which students receive information and produce a response (Lindsley, 1990). A description of both the sensory input and output channels are called *pinpoints* (Lindsley, 1972). The see/say channels are used during intervention training. Tasks involving *see/say channels* involve a student “seeing” a stimulus and “saying” a response (Lindsley, 1991b). In Study 1 a “see the lower case letter/say the letter sound” pinpoint describes the task for the pre-primary children. For the Year 2 children in Study 1 and the participants in Study 2, a “see the digraph/say the digraph sound” pinpoint describes the task used during intervention training. Thus, rates during training and on the retention, endurance, stability and application measures are termed *see/say rates* which are descriptions of the number of see/say responses per minute or phonemes per minute (ppm).

Adduction is measured on tasks involving one learning-channel and two learning-channel crosses. A *one-channel cross* involves the probing of adduction when one learning channel in the adduction task differs from one learning channel in the training task. The Adduction 1 measures involve *hear/say learning channels* in which the input channel on the adduction task differs from the “see” input channel in the training task. The Adduction 1 task in Study 1 is described by the pinpoint “hear the pseudoword/say the phonemes”. In Study 2, the Adduction 1 task comprises the pinpoint “hear the pseudoword/say the letter names”. Therefore, rates on these tests are described as *hear/say rates* which referred to the number of hear/say responses per minute and were again expressed as phonemes per minute (ppm). A *two-channel cross* involves the assessment of adduction when both learning channels differ in the adduction task from the channels involved in the training task. The Adduction 2 measures thus involve *hear/mark learning channels* in which both the input and output learning channels differ from the “see” and “say” learning channels involved in the training task. The Adduction 2 task is defined by the pinpoint “hear the pseudoword/mark the phonemes”. Therefore, rates on these measures are expressed as *hear/mark rates* which describe the number of hear/mark responses per minute. These are also expressed as the number of phonemes per minute (ppm).

Study 1 compares the effectiveness of two rate training techniques and comprised two experimental conditions. In the *rate-building (RB) condition* the children are immediately involved in exercises aimed at increasing see/say rates. In the *rate-building after accuracy training (RBAAT) condition* the children are first trained to read the phonemes with 100% accuracy on two consecutive trials and are then involved in the same rate-building exercises as are implemented in the RB condition.

In Study 2, the effects of free-operant speeded practice are compared to constrained-rate repeated practice. In the *rate-building (RB) condition* the children are immediately involved in rate-building exercises to increase the rates of see/say responses. In the *constrained-rate repeated practice (CRP) condition* the participants are involved in fixed slow-paced repeated practice on discrete trials.

The accuracy training stage in the RBAAT condition in Study 1 and the CRP condition in Study 2 involves training on discrete trials under constrained-operant conditions. *Discrete trials* involve teacher or researcher controlled presentations of discriminative stimuli (Alberto & Troutman, 1990). The learner responds once to the stimulus and reinforcers are presented contingent upon a correct response. The next stimulus is then presented after an interval under teacher or experimenter control (Johnson & Layng, 1996). Under *constrained-operant conditions* the presentation of the discriminative stimuli is not learner controlled and reinforcement occurs after the demonstration of a discrete and accurate response (Binder, 1996). In these studies, stimulus presentation under constrained-operant conditions is every three seconds.

In the RB conditions in both studies the children train under free-operant conditions. Free-operant conditioning is a method of learning in which learners are free to self-pace stimuli and responses without having constraints imposed on their response rates by restrictions of the materials or the instructional techniques implemented (Lindsley, 1990). In contrast to discrete trial training, in *free-operant conditioning* procedures there are no trials but rather a particular duration of time is specified during which the learner is free to self-present and to self-pace the discriminative stimuli and to build the speed of responding (Lindsley, 1996a; Leach, Coyle, & Cole, 2003).

The results of the research are discussed within a selectionist framework. Skinner first applied Darwin's principles of natural selection to the analysis of behavioural changes of an individual over a lifetime (Skinner, 1974; 1989; Pennypacker, 1992; Johnson & Layng, 1992; 1994). The fundamental premise underpinning the *selectionist framework* is that behaviours are selected by their consequences (Pierce & Epling, 1995). That is, the behaviour of an individual interacts with the environment and this has the effect of producing certain consequences. Consequences that are desirable to an individual have the effect of increasing the behaviours which brought about such consequences, whilst consequences that have a negative value for the individual produce decreases in behaviours that generate such consequences. Skinner proposed the operant-conditioning model based on the principles of such environmental selection (Pierce & Epling, 1995).

The operant-conditioning model is used to explain the findings of the current studies. *Operant conditioning* involves the interaction of operants with contingent reinforcement and refers to the presentation of a consequence after a response or behaviour is demonstrated by an individual (Wolery, Bailey & Sugai, 1988). Operant conditioning, therefore, describes a process whereby the selection or strengthening of behaviour occurs when that behaviour has a reinforcer as its consequence (Skinner, 1989). *Operants* are units of behaviour consisting of responses that interact with the environment (Pierce & Epling, 1995). *Contingent reinforcement* refers to the presentation of reinforcers when a target behaviour is demonstrated (Wolery, Bailey & Sugai, 1988). *Reinforcers* are consequences that increase the future probability of a behaviour or response (Skinner, 1953; 1974).

Two forms of differential reinforcement are discussed in relation to the results of the research. *Differential reinforcement* is the contingent presentation of a reinforcer after the demonstration of a target behaviour and the withholding of reinforcers when the target behaviour does not occur (Wolery, Bailey & Sugai, 1988). *Differential reinforcement for discrimination* is the presentation of a reinforcer following an accurate response in the presence of a particular discriminative stimulus and the withholding of reinforcers when the appropriate response does not occur in the presence of the stimulus (Alberto & Troutman, 1990). This form of differential reinforcement is used to teach the participants to produce the appropriate phonemes in response to each printed letter or digraph. The withholding of reinforcers after the demonstration of inappropriate responses decreases the rate of occurrence of these behaviours, a process termed *extinction*. *Differential reinforcement for shaping* is the presentation of a reinforcer for a response that meets a specific criterion and the withholding of reinforcers when the response does not meet the criterion (Alberto & Troutman, 1990). This form of differential reinforcement is used to shape accurate see/say responses to accurate see/say rates. Thus, *shaping* is the differential reinforcement of successive approximations to a target behaviour (Ferster, Culbertson, & Boren, 1975).

Overlearning and automaticity theories are also cited in the analysis of the research findings. *Overlearning* is the provision of additional learning trials and overtraining of a skill beyond the 100% accuracy criterion (Driskell, Willis, & Cooper, 1992; Binder, 1996). *Automaticity* refers to the attainment of fast, “unconscious” movement in so far as the learner’s conscious attention is not required during the skill performance (Bloom, 1989; Bucklin, Dickinson, & Brethower, 2000).

Relevant concepts and theories relating to the current research project have been introduced in this chapter. Only very brief descriptions and definitions have been provided. The following chapter contains a review of the relevant literature and each concept is further elaborated. In the review, the issues that are still in need of investigation through controlled empirical research are highlighted. Briefly, these issues relate to inconsistencies in the definition and conceptualization of fluency and in measures designed to assess fluent performance. Although researchers agree that fluent performance is characterized by adequate speeds of accurate responding, methods of specifying “adequate”, or proficient rates of performance vary markedly in rate-building literature. This has resulted in inconsistent recommendations of proficient rates. Johnson and Layng (1992; 1994; 1996) have proposed the RESAA model for the operationalization of fluency in terms of the specification of response rates that predict or optimize skill retention, endurance, stability, application and adduction. However, this model has not been adequately researched under controlled experimental conditions. Moreover, limitations in most studies involving rate-building procedures, such as the lack of controls for practice and reinforcement effects, have restricted the interpretation and application of these results in practice. The current research aimed to specifically address these issues and to provide empirical evidence upon which to base some clear guidelines for the implementation of rate-based procedures and measures of learning by teachers, researchers and other practitioners.

Note: Sections of the literature review that were prepared for this thesis and that are included in Chapter 2 were published in a chapter by Leach, Coyle and Cole (2003). Appropriate reference is made to the published chapter in specific sections of Chapter 2 in this thesis. The results of Study 1 were presented by Coyle (2004) at the ABPMC (Brazilian Association for Psychotherapy and Behavioral Medicine) and the ABA (Association for Behavior Analysis) International Conference (2004) in Campinas, Brazil.

CHAPTER 2

LITERATURE REVIEW

The review in this chapter follows the development of rate-building research from Skinner's contributions of rate of response and free-operant conditioning, and its origins in Precision Teaching, to the more recent investigation of fluency as characterized by observable, behavioural learning outcomes. The review analyses research involving rate-building procedures aimed to produce "fluent" academic skills, with a focus on reading. The literature that is reviewed is largely conceptual in nature as it will be shown that there is limited empirical research available into the specific effects of increased response rates on learning outcomes. However, empirical research that is available and relevant to the current research project is presented. Descriptions of rate-building procedures often include references to research evidence obtained from other non-behavioural fields of study. These are also reviewed.

Origins of fluency research in education

Fluency research originated from Skinner's early work with pigeons and rats in the 1930's and in the behavioural laboratories of the 1950's (Skinner, 1953; Lindsley, 1972; 1991a; Potts, Eshleman & Cooper, 1993). The free-operant paradigm and rate of response are two concepts that were derived from these initial studies of animal behaviour. These concepts are interrelated and are integral in the behavioural construct of fluency.

Skinner (1953) noted that a common limitation in behavioural science was the observation of single events that occurred in only one moment in time. As time is a fundamental aspect in the measurement of behaviours that change, it was recommended that time dimensions be included in measures of performance (Haughton, 1972; Binder, 1990b). Skinner began to use rate of response in the animal laboratories and recorded rates of lever pressing by rats and key pecking by pigeons (Lindsley, 1991b). Skinner wanted to avoid imposing constraints on response rates by materials or environmental conditions. The development of apparatus, later termed the "Skinner box", that removed all external restrictions on response rates led to the development of the "free-operant" (Ferster, 1953). Ferster (1953, p. 263) described the Skinner box as a "method of research employing the free-operant…. that generates a response which takes a short time to occur and leaves the animal in the same place ready to respond again". Thus, in free-operant performance the emphasis is on the production of a continuous flow of rapid responses over a period of time (Binder, 1996). Lindsley (1991a) noted that the continuous nature of monitoring in the free-operant procedure often allowed the observation of subtle behavioural variations that in discrete trial techniques may have occurred between trials.

Other researchers noted the advantage of the free-operant over discrete trials training. During the 1970's Binder and his associates worked with students to teach prevocational and preacademic skills (Binder, 1996). They shifted from discrete trials training and developed procedures and materials that allowed freer-operant responding. Binder (1996) reported the observed benefits of such a shift using the example of teaching word naming. He moved from teaching one word at a time in trials to laying the words out in an array on the table, which allowed for freer-operant responding. Binder and his colleagues found that the rates of correct responding generally tripled without any additional intervention (Binder, 1996).

The free-operant technique was emphasized by Lindsley (1996a) when he described the "four free-operant freedoms". The freedom to self-present stimuli comprised one of the free-operant freedoms. Learners are free to self-present and self-pace the discriminative stimuli and, therefore, their response rates are not restricted by time constraints imposed by external presentation of the stimuli. In contrast, in discrete trials the learner has an opportunity to respond, followed by an interval during which he or she must wait for the presentation of the next stimulus. Binder (1996) asserted that in such procedures students are repeatedly forced to stop and start responding in a manner that does not reflect the normal stream of behaviour. Lindsley (1996a) developed the acronym SAFMEDS ("say all fast a minute each day shuffled"; p. 203) to describe his use of cards, utilized in training rates of target skills, that displayed the discriminative stimuli on one side and the correct responses on the other. He found that when another individual held the cards for a student, his rate generally decreased to half the rate that same student could achieve when he held the cards himself (Lindsley, 1996a).

Another advantage of allowing students to self present stimuli is the fostering of response rhythms which are critical in developing high response rates (Lindsley, 1996a). Lindsley (1996a) recalled his attempts to increase learners' response speeds through external pacing, such as tapping on the table or using a metronome. He conveyed that all external pacing attempts failed as they broke the learners' natural rhythms and distracted them from increasing response speeds. Lindsley (1996a) also described a study by a graduate student of Skinner's named Alfredo Lagmay. He made reinforcement for pigeons contingent upon pecking at a steady, externally paced rate. He found that whilst the schedule would ordinarily have produced high pecking rates, the external pacing generated sudden bursts of responses that could not be maintained.

He showed that learners' own rhythmical patterns of responding are necessary in building rate and they cannot endure external pacing for long periods.

A third advantage of the self-presentation of discriminative stimuli described by Lindsley (1996a) is the freedom to "skip". He maintained that the steepest accelerations in learning rates are achieved when learners begin at high overall rates and low accuracy. Thus, when learners encounter a stimulus for which they are unable to provide a response, they are allowed to "skip" that stimulus in order to continue the stream of responses for the remaining stimuli.

The freedom to repeat responses many times to each discriminative stimulus is another of the four free-operant freedoms described by Lindsley (1996a). The repeating of responses in this way allows teachers to directly and continuously measure the "degree of assurance to each signal in a discrimination experiment" (Lindsley, 1996a, p. 206). Lindsley noted that there was no requirement for statistical calculations when continuous responding under free-operant conditions was recorded. Therefore, the advantage of repeated responding was emphasized.

The freedom to speed was also described as one of the four freedoms by Lindsley (1996a). He related the early problems encountered by Skinner and his colleagues concerning ceilings imposed on response rates by the operanda used in the experiments. For example, when initially studying the pecking behaviour of pigeons, the apparatus used involved a lever which dipped into a cup of mercury. The delay of one second between opportunities to press the lever, caused by the design of the apparatus, imposed a ceiling of 60 responses per minute. Likewise, Lindsley (1996a) noted that some of the attempts to apply computer methods of instruction imposed ceilings on response rates because of the time intervals between the screen changes.

Thus, the importance of ensuring that instructional materials do not restrict rate was highlighted.

The last of the free-operant freedoms depicted by Lindsley (1996a) was the freedom to form responses. He explained how students should be allowed to abbreviate responses in order to increase rate. He provided an example involving the response “increase”. If a student was involved in a point/see/write task, Lindsley indicated that an arrow written in the upward direction in place of the word “increase” should be allowed as a correct response. The student thus selects his own response form that is quicker to perform than writing the whole word, and which allows the student to achieve higher response rates.

Although the advantages of rate measures were apparent, Skinner and his colleagues originally neglected rate of response in their early studies of instructional schedules and instead favoured percentage correct measures (Binder, 1996; Lindsley, 1992a). However, Lindsley, who was a doctoral student of Skinner’s at Harvard, maintained his commitment to rate of response. He was the first to apply the free-operant procedure and rate of response in the study of psychophysiology and Skinner was his major advisor (Potts, Eshleman & Cooper, 1993). In 1953, Lindsley established the first human operant laboratory in Massachusetts and experimentally studied the behaviour of individuals with schizophrenia. He noted that in these free-operant laboratories, rate of response was always up to 50 times more sensitive to drug changes than percentage measures (Lindsley, 1992a).

Lindsley later accepted a professorship in special education at the University of Kansas and founded Precision Teaching (Potts, Eshleman & Cooper, 1993; Lindsley, 1991a). Precision Teaching is a data-based approach to teaching and learning.

Educational decisions are based on changes in response rates and learning rates that are displayed on standard celeration charts (Binder & Watkins, 1989; West, Young & Spooner, 1990; Binder 1990b). Fundamental features of precision teaching are time-based mastery criteria, opportunities for practice and timed-performance, use of the free-operant in structured techniques and rate of response performance measures (Binder, 1988; White, 1986; Lindsley, 1992a). Lindsley (1991a) reported that, in his experience in precision teaching, he found rate measures to be 40 times more sensitive to curriculum changes than percentage correct scores.

A large-scale project was conducted in the 1970's in Great Falls, Montana. A description of the Great Falls Precision Teaching Project was provided by Beck and Clement (1991). The goal of the project was to demonstrate the efficacy of precision teaching to the US Office of Education's joint Dissemination and Review Panel. The research was longitudinal and included students in both mainstream and special education classrooms. The effects of precision teaching with children with mild disabilities were studied across a range of curriculum areas in 1975. The project extended over the academic school year and took place in six schools. The results showed that 15 out of the 19 (79%) of the experimental-control group comparisons indicated significantly superior performance of the experimental group on the post-tests. The performance of one group had equalled the performance of a control group that initially demonstrated superior performance. Another longitudinal study in the project assessed the effects of precision teaching on first, second, third and fourth grade students in mainstream classrooms in 1979. The results revealed that these students scored 20 and 40 percentile points higher in reading and in mathematics respectively than other children in the district on the IOWA Test of Basic Skills. Additionally, a follow-up study was conducted three years after the project was completed. The results demonstrated that there was no regression in achievement gains for the groups trained through precision teaching.

A similar project was conducted in Tacoma, Washington, called the State of Washington Child Service Demonstration Program (Howell, Kaplan & O'Connell, 1979). The Program screened 11,000 children and the results showed that students with low rates of performance of basic skills were the individuals most frequently referred to special education and identified as needing remedial help. It was concluded from the study that high rates of accurate performance in basic skills, such as saying phonemes, resulted in longer skill maintenance without practice.

Although the current research project does not involve precision teaching per se, the interventions do emphasize some of the fundamental elements of the approach, such as increasing response rates, using rate of response measures and utilization of freer-operant procedures. It was important to review some of the literature on precision teaching as it was precision teaching practitioners that initiated the first advances towards the current conceptualizations of fluency.

The development of conceptualizations of fluency

Advances towards contemporary conceptualizations of fluency originated in the work of Eric Haughton. Haughton was a student of Lindsley's and a practitioner of precision teaching (Lindsley, 1996b). Lindsley initially urged the continuous monitoring of classroom behaviour, but Haughton moved to monitoring only 10-minute samples of behaviour in order for it to be practicable for teachers to time all students throughout the day (Lindsley, 1996b). Haughton (1972) then advocated using several one-minute timings for various skill performances, initially with the intention of diagnosing areas in which a child required most assistance (Lindsley, 1996b). The implementation of one-minute timings by other practitioners, such as Kunzelmann, Starlin and Gaasholt (Haughton, 1972), led to the emergence of observations that influenced the development of the concepts of component-composite skill relations and proficiency aims.

Component-composite relations

Haughton (1972) recounts an experience at the Twin Oaks School in Oregon that was instrumental in forming notions of component-composite skill relations. Whilst reviewing the data from a sixth-grade classroom, Haughton was perplexed as to why some of the students could not attain the performance aims in maths computation that their classmates were achieving. When he assessed the rate at which these individuals wrote digits, he found their rates to be below 20 per minute. Increasing the rates of digit writing resulted in accelerations in their maths computation data and these students quickly attained the set aims. Other practitioners had made similar discoveries. For example, Starlin found that the students who progressed most quickly through the reading curriculum were those children who read letter sounds from a list at above 40 per minute (Haughton, 1972). Gassholt reported observations that students who performed at a rate of above 30 digits per minute in maths computation exercises advanced to more complex maths tasks with relative ease (Haughton, 1972). However, those who performed at rates of less than 20 per minute showed steady decelerations in rate as they moved to more complex maths tasks. These observations led to the idea that success in mastering more complex skills relied on the achievement of specific pre-requisite, or component, skills. Haughton (1972) assigned the name “tool skills” to describe the most basic elements or components of more complex composite skills.

It is now widely accepted by behavioural practitioners that higher rates of component skills produce greater accelerations of the more complex composite skills of which the components are a part (Leach, Coyle & Cole, 2003; Binder, 1988; 1996; Leach, 1996; Johnson & Layng, 1992; 1994; 1996; Dougherty & Johnston, 1996; Freeman & Haughton, 1993; Haughton, 1972; Starlin, 1972). Likewise, it is well established that ceilings are imposed on the acceleration of composite behaviour rates when tool skills or other component skills are performed at low rates (Binder, 1996). These understandings led to the investigation of rate aims or rate criteria.

Rate criteria

The concept of rate criteria was first introduced by Haughton (1972) and his colleagues after observing that high rates of component skills led to higher rates of the more complex composite skills. Since then some researchers have demonstrated that the specification of rate criteria produces improved learning outcomes (Bucklin, Dickinson & Brethower, 2000; Omrod & Spivey, 1990; Shirley & Pennypacker, 1994). Rate criteria are performance aims and are expressed as the number of correct responses per minute.

Shirley & Pennypacker (1994) compared the effects of different performance criteria on the acquisition and retention of spelling words. The study involved two boys who were aged 15 years and 14 years and were full-time students in special education classes. The boys were trained to spell words from lists of 10 words. The effects of repeated practice and timed performance under three conditions were investigated. One list of spelling words was practiced with no specification of a criterion, one was practiced to a 100% accuracy criterion and another list was trained to rate criteria of 91 per minute and 105 per minute for each participant respectively with 100% accuracy.

The researchers controlled for the effects of daily practice sessions by providing a second "yoked" spelling list in the accuracy criterion and rate criterion conditions. This list also contained ten spelling words that were different from the separate target list of spelling words. The students were also trained on the yoked lists but criteria were <u>not</u> specified for these spelling lists. Thus, it was possible for the researchers to directly compare the effects of the different criteria when practice was controlled.

The findings of Shirley and Pennypacker's (1994) study showed that implementation of the accuracy criterion, after training to no criterion, produced improvements in both the accuracy and correct spelling rates (number of letters per minute) for each participant. However, the implementation of the rate criteria produced the most dramatic improvements with an approximate doubling in correct spelling rates for both participants. The participants' rates were consistently higher on the lists for which the rate criteria were implemented than on the lists in the other conditions both across and within phases. The retention data that were collected 10 days after the termination of the intervention revealed that the rate criterion produced superior retention rates than the accuracy-only criterion. Although the results indicated improved spelling performance when rate criteria were implemented, there were only two participants involved in the study and definite conclusions could not be drawn from such a small sample. However, the results are consistent with other studies that have compared performance when the implementation of accuracy-only criteria is compared to rate criteria (Bucklin, Dickinson & Brethower, 2000; Omrod & Spivey, 1990).

The rate criteria in Shirley & Pennypacker's (1992) study were termed "fluency criteria". These rates were based on measures of the students' "fluent" writing performances as indicated by the rates at which they wrote their names. The terminology and procedure for setting rate criteria in this study highlighted two common problems that pervade the fluency literature. The first concerns the range and misuse of terms used to describe common concepts and the second relates to the various methods of setting rate criteria.

Rate criteria have been referred to by many other names in the rate-building literature. As was noted by Leach, Coyle & Cole (2003) these names usually comprise the pairing of the terms performance, frequency, proficiency, fluency and instructional with the terms criteria, standards and aims, and some refer to desired or optimum performance rates (Evans, Mercer & Evans, 1983; Koorland, Keel & Ueberhorst, 1990; Lindsley, 1996b; Haughton, 1972; McDowell & Keenan, 2001; Binder, 1996; Howell & Morehead, 1987; Bateman, 1971; Ivarie, 1986; Carnine, Silbert & Kameenui, 1997; Herman, 1985). These terms are often used interchangeably and can often have different meanings in various contexts which can be very confusing to practitioners.

An example of the diversity in terminology and the confusion it creates is provided by Leach, Coyle and Cole (2003). Johnson and Layng (1996) asserted that teachers should specify “fluency aims” or “performance standards” that predict the RESAA outcomes. They elaborate by indicating that when a “frequency aim” meets these criteria it then becomes a “fluency aim”. However, one particular performance rate may not ensure the same level of performance on the RESAA measures for one learner as for another. Therefore, whilst the rate criteria set for one individual may be a “fluency aim” because it ensures fluent performance, the same rate criteria may not be a “fluency aim” for another learner because it does not ensure fluent performance and the term would be misused in this instance. Even if the term “fluency aim” was only applied to refer to the criteria that ensured fluent performance for one individual it could only be confirmed as such after the learner had achieved the aim and the effects of that particular performance rate on the RESAA measures had been assessed. It must be questioned what the function is in renaming the rate criteria after the learner has already achieved it. Similarly, in Shirley and Pennypacker's (1994) study, the term "fluency criteria" suggests the specification of particular performance rates that ensure fluent performance. However, there were no measures that ascertained whether these rate criteria did produce fluent performance. The criteria were set based on the participants' "fluent" name-writing performance, but there were no measures that ensured the students' name-writing was "fluent" either. The researchers simply measured the rate at which each participant wrote their names without assessing whether these rates were sufficient to ensure any of the learning outcomes depicted in the RESAA criteria.

An array of methods for setting optimum rate criteria for a range of skills has been postulated in the fluency literature. Various forms of norm-referenced procedures have been suggested, such as calculating the mean performance rates of experts in a particular field (Aulls, 1978), using mean performance rates of successful peers (Howell & Howell, 1990) and utilizing adult/child frequencies in proportion formulae (Shirley & Pennypacker, 1994; Koorland, Keel & Ueberhorst, 1990; Mercer, Mercer & Evans, 1986). The results of some of the large-scale research projects, such as the Great Falls Precision Teaching Project and the State of Washington Child Service Demonstration Program, have also been used to propose optimum rates of performance for various skills (Beck & Clement, 1991; Howell, Kaplan & O'Connell, 1979). Other researchers have empirically investigated the effects of specific rates of performance on various learning outcomes and drawn conclusions concerning optimum performance rates for different skills (Evans & Evans, 1985; Evans, Mercer & Evans, 1983; Ivarie, 1986).

Some empirical studies have demonstrated the effectiveness of higher compared to lower rate criteria in improving competence of some skills. For example, a study conducted by Evans, Mercer and Evans (1983) investigated the effects of building low (40 per minute), medium (60 per minute) and high (80 per minute) rates of reading letter sounds on subsequent word reading (C-V-C trigrams). The research involved nine children with learning disabilities in second through fifth grade. The participants were randomly assigned to the low, medium and high frequency experimental groups, with three children in each group. The median correct scores on the first and last three C-V-C trigram timings in the post-test phase were compared within participants using add-subtract gain scores. The results indicated that the group trained to the high frequency had the highest total gain of 58 words read correctly. The medium frequency group demonstrated the lowest total gain of 30 words read correctly. The researchers also compared the median correct scores of the first two C-V-C timings during the pre-test phase to the median of the last three timings during the post-test phase within participants using add-subtract gain scores. These results showed that the high frequency group had the highest gain of 107 words, whilst the medium frequency group had the lowest total gain of 36 words. However, there were no such comparisons reported for the low frequency group. This research demonstrated that the highest rates of see/say phonemes produced the greatest gains in the number of words read correctly. However, the medium frequency group demonstrated the poorest performance on the see/say words task, even though they had trained to higher see/say rates than the low frequency group. Thus, the results did not conclusively support the claim that the higher the component skill rates, the higher the rates on the composite skill measures. The reliability of these results may have been limited by the inclusion of only three individuals in each group and the use of only pre-test and post-test group data. For example, one of the three participants in the low frequency group may have demonstrated particularly superior performance on one of the C-V-C tests which may have inflated the scores for this group and implied a trend that was possibly not reflected in any of the other participants' data. As individual data were not reported in the study, it was impossible to ascertain whether such instances occurred.

Ivarie (1986) also conducted a study that demonstrated improved outcomes when higher rate criteria were achieved compared to when lower rate criteria were attained. The study involved 120 fourth-grade students and investigated the effects on skill retention of training an Arabic-Roman numeral correspondence task to two rates of performance. The children were randomly assigned to rate criteria of 35 responses per minute or 70 responses per minute. The data included a comparison of percentage correct response means and a comparison of retention means. The results indicated that the group of children assigned to the 70 responses per minute condition demonstrated superior performance after three months compared to the children assigned to the 35 responses per minute condition.

The results of a study by Evans and Evans (1985), however, rejected other findings that the highest training rates achieved by participants produced the most improvements in the targeted outcomes. Extending their earlier study (Evans, Mercer & Evans, 1983), Evans and Evans (1985) again trained nine first-grade children to read letter sounds to three different rate criteria and assessed the effects on subsequent C-V-C word reading. The rate criteria were set at higher levels than in the previous study. The children were trained to low (60 per minute), medium (90 per minute) or high (120 per minute) skill frequencies. The researchers also controlled for practice effects by matching phoneme repetitions for each child. When the first participant in the high frequency group attained the aim of 120 correct sounds per minute, his rate was maintained using a controlled reader for subsequent timings until he said a total of 1206 sounds. The researchers then ensured that each of the other children received the same number of phoneme repetitions, so that each had the same quantity of practice in saying the sounds. Thus, the results could be attributed to the effects of the training rates and not to increased practice by the children training to the higher rate criteria. The results, however, showed that the highest total gains in words read correctly were achieved by the medium frequency (90 per minute) group and that the lowest gains were actually attained by the highest frequency (120 per minute) group. The researchers concluded that 90 sounds per minute was the optimum performance rate of reading sounds to ensure the most superior improvements on the more complex word reading composite task. The researchers did not include an explanation for these results in the published article and there was insufficient information included to begin to understand or explain them. As in their previous study, the reliability of these results may have been limited by the inclusion of only three participants in each group and the use of only group-based pre-test and post-test data.

Some of the optimal training rate aims for specific skills that have been recommended in other publications are summarized in Tables 2.1 and 2.2 in Appendix 1. Only those recommendations relating to reading, writing and spelling have been included as these skills are the focus of the current research. Table 2.1 lists some of the rate criteria that have been either used in empirical studies or have been suggested as optimal rates from empirical studies. Table 2.2 includes recommendations for optimal performance rates that have been cited in non-empirically based articles, such as in papers describing authors' personal teaching experiences. Table 2.2 shows that many of the optimum rates advocated by researchers and practitioners are based on personal experience or on the opinion of others. The original sources of these recommendations were followed back as far as possible, but it was often the case that the original sources of the information were unattainable. The summary tables also show the inconsistencies in recommendations for optimal performance rates for various literacy skills. For example, Mercer and Mercer (1993) suggested rate aims of 36 to 52 per minute as proficient rates of see/say phonemes for children in kindergarten through to third grade. On the other hand, the large-scale Intermediate School District No. lll, Child Service Demonstration Project (Howell, Kaplan & O'Connell, 1979) specified rates of between 80 and 100 per minute for see/say phonemes by children of the same age. Tables 2.1 and 2.2 in Appendix 1 show that researchers are frequently of the view that higher performance rates are required of older learners than younger learners (but suggestions of optimal rates are often only available for specific aged children for specific skills).

Many researchers have noted the inconsistencies concerning optimal performance rates that ensure proficient performance standards and have emphasized that there is currently no consensus concerning the precise criteria for fluency (Rasinski, 1989; Lipson & Lang, 1991; Reutzel & Hollingsworth, 1993; Rasinski, Padak, Linek & Sturtevant, 1994; Johnson & Layng, 1996; Worthy & Broaddus, 2002). The search for optimum response rate criteria has been led more recently by Johnson and Layng (1992; 1994; 1996) and they have pioneered advancements in the measurement and conceptualization of fluency. They have focused on operationalizing fluency and have proposed the specification of rate aims that predict a set of specific learning outcomes as functional criteria for fluency. These criteria have developed over the years and are based on earlier conceptualizations of proficient performance proposed by Haughton. Binder (1988; 1990a; 1990b; 1991; 1993; 1996) has been active in disseminating these advances and in recommending further research to empirically validate such a construct of fluency.

Operational definitions of fluency

Operational definitions of fluency began to emerge in the early 1980's, whereby performance rates that optimized specific learning outcomes became the functional criteria for fluent performance. In 1981 Haughton coined the acronym R/APS (Retention/Application Performance Standards) to indicate that rate aims, or rate criteria, must specify performance rates that ensure performance standards, such as the retention and application of the skill (Lindsley, 1996b). Later the acronym was expanded to REAPS (Retention, Endurance and Application Performance Standards) to include a third outcome of rate-building (endurance) which referred to the learner's ability to perform the skill at the same rate over longer periods of time than during training. Haughton later converted the 'S' in REAPS to represent "stability", when researchers found that increased response rates produced performance that remained stable in the presence of distraction (Lindsley, 1996b).

More recently, operational definitions of fluency have included the relatively new concept of contingency adduction. Adduction occurs when learners demonstrate new, previously untaught composite responses after building high rates of the necessary component skills (Binder, 1996; Leach, 1996). This generative effect has led to the "curriculum leaps" reported by Johnson and Layng and to accelerated learning rates for students who have been labelled with learning disabilities and attention disorders, or for other students who have previously experienced school failure (Johnson & Layng, 1992; 1994; Binder & Watkins, 1989). Curriculum leaps refer to the spontaneous advancement in a curriculum to new instructional objectives as a result of cumulative response frequencies and high rates of component skills (Lindsley, 1990; Johnson & Layng, 1992; 1994). This phenomenon is the principle underpinning the Generative Instruction Model implemented at the Morningside Academy and Malcolm X College reported by Johnson (1991) and Johnson and Layng (1992; 1994).

Sidman (1971) demonstrated the stimulus equivalence model which, to some extent, has paralleled the development of the adduction model. Sidman (1971) taught a participant to match pictures (B) with their dictated names (A). The participant was also taught to name the pictures (BD). Next, the participant was trained to match the printed names to the dictated names (AC). The researcher found that the BC (printed names to pictures) relation, the CB (pictures to printed names) relation and the CD (oral naming of printed words) relation developed without explicit training. The forming of new relations in this way demonstrates the adduction of new, previously untaught composite skills that produce the curriculum leaps as described by Lindsley (1990) and Johnson and Layng (1992; 1994).

The current acronym used to represent fluent performance standards is RESAA, which includes adduction as one of the outcomes of rate-building to increased rates of performance on component skills. The development of this recent and most comprehensive set of fluency criteria was described by Johnson and Layng (1996). Fluent performance is determined by the specification of performance rates that ensure the achievement of the set of RESAA (retention, endurance, stability, application and adduction) outcomes or standards. Thus, the RESAA criteria depict standards of “true mastery" that specify proficient, useful, generalizable performance (Leach, Coyle & Cole, 2003; Binder, 1990a; 1996; Binder & Bloom, 1989).

An important clarification concerning the term "fluency" and associated learning outcomes was made by Binder (2004). He responded to a review of the effects of rate-building on fluent performance by Doughty, Chase and O'Shields (2004) and stated that an error was made by Doughty et al. (2004) regarding Haughton's REAPS acronym in which the "S" was printed as "s". Doughty et al. claimed that the acronym depicted possible learning outcomes described as "retention, endurance, application, and performance standards" (Binder, 2004; p. 283). Binder (2004) clarified that the acronym actually presented a challenge from Haughton to identify response rate ranges that optimized retention, endurance and application. Binder (2004) suggested that Doughty et al. (2004) defined the term "fluency" separate from the time dimension and Binder maintained that emphasizing retention, endurance, and application as outcomes related to achieving competent response rates was confusing. The important clarification made by Binder (2004) is that it is a misrepresentation of the term "fluency" to describe the attainment of skill fluency as a separate dimension of behaviour, and then to assert that this "fluent" performance produces the outcomes depicted in the RESAA criteria. Rather, the term "fluency" refers to the attainment of particular rates of component skills that promote or predict the achievement of the learning outcomes described in the RESAA criteria. Fluency is not a "state" that is achieved and then produces the RESAA outcomes. The term refers to truly mastered performance that is achieved when response rates are sufficient to optimize these RESAA outcomes. Thus, "the empirical definition of fluency is related to its measured effects" (Binder, 1996, p. 164).

Learning channels

Early precision teachers began to operationalize learning tasks by specifying the sensory dimensions of the antecedent stimuli and the topographical dimensions of responses (Binder, 1996; Johnson & Layng, 1996). These descriptions were expressed as statements called learning channels (Johnson & Layng, 1996). Originally only "out" (response) channels were specified. Verbs such as "say", "touch" and "mark" were used to describe the types of movements involved in specific responses (Binder, 1996). Later the "in" channels were also specified to indicate the sensory channel by which learners received the antecedent stimuli. Verbs such as "hear", "see" and "taste" were used to describe these learning channels (Binder, 1996). The term "pinpoint" was used to describe a statement comprising the learning channel and stimulus control topography (Lindsley, 1972).

Lindsley (1994) described the earlier research in the 1970's and 1980's when Keller conducted studies on learning channels at the Spaulding Youth Centre in New Hampshire with emotionally disturbed and autistic children. They found that learning of spatial relationships in one channel was relatively independent of learning the same skill in another channel. The departure of the director from the Spaulding Youth Centre brought the research to a close and it was not continued at the centre nor has it been continued elsewhere ever since (Lindsley, 1994). Around the same time International Management Systems (IMS), a private corporation, created and sold a computerized screening system for use in public school special education programs (Lindsley, 1994). The program was an adaptation of the methods Lindsley and his colleagues had employed at the University of Kansas. The students were required to practice a task for one minute in each of the see/write, see/say and hear/write channels every day over a period of ten days. The researchers aimed to identify the channel with the steepest learning and then to provide instruction in that channel and remediate the channel with the most inferior learning. Unfortunately, IMS corporate did not survive and the research was not completed (Lindsley, 1994).

Eric Haughton also conducted investigations into learning channels and eventually created the learning channel matrix in 1980 (Lindsley, 1994). The matrix consisted of a grid that listed verbs describing the possible inputs of stimuli on the left and those describing outputs of responses at the foot (Binder, 1996). He was involved in intensive research with a wide range of learning channels until he became terminally ill and this research also ceased (Lindsley, 1994).

An empirical study by Bolich and Sweeney (1996) investigated the use of see/write, think/write and see/say channels in combination with repeated reading and precision teaching measurement procedures to improve the reading "fluency" of Hebrew of an eleven-year old girl. The child was taught to write the Hebrew alphabet in the see/write channel. She was given a ruler that displayed the 32 characters of the alphabet and was involved in at least 10 minutes of practice in writing the alphabet per session, after which two one-minute timings of performance were conducted. An aim of 60 letters per minute was specified, based on the performance of an experienced student who demonstrated a rate of 64 letters per minute. The participant reached the aim for the see/write channel within the first few sessions and, thus, the channel changed to a think/write channel. In the next intervention phase, the researchers used cards on which printed Hebrew letters appeared on one side and the corresponding vowels or consonants were printed on the other side. The child was required to see/say as many of the Hebrew sounds as possible and Bolich and Sweeney (1996) selected an aim of 60 sounds per minute, based on suggested performance standards from the Intermediate School District No III. The final phase of instruction also involved the see/say channels and required the participant to repeatedly read selections of Hebrew passages. An aim of 160 words per minute was specified based on the performances of an adult and two teenagers who were considered proficient readers of Hebrew.

The results of Bolich and Sweeney's (1996) study indicated accelerated learning rates and decelerations in error rates in each phase of the intervention. The participant achieved the aims in each phase. However, the researchers did not compare training in different channels nor did they assess the effects of changing channels on performance. Thus, it was not possible to draw conclusions concerning the independence of learning in one channel compared to another, nor was it possible to ascertain which channel produced the best performance rates. On the other hand, the study did provide an illustration of the provision of multiple practice opportunities of a skill through different learning channels. Although learning channel analysis has proved to be a useful tool for planning practice activities for particular skills (Binder, 1996), for specifying instructional procedures in unambiguous terms (Binder, 1996) and has indicated implications for teaching in multiple channels (Lindsley, 1994; 1998), it remains an area of limited research and application (Lindsley 1994; 1998). Lindsley has repeatedly encouraged further research into learning channels and their application to education (Lindsley, 1994; 1998).

Shrivastava (2000) responded to the recommendations for research into learning channels, and applied learning channel analysis to probe adduction in two studies. She asserted that "if a trained task is defined in terms of its learning channels, related tasks will consist of within-channel similarities and across-channel differences" (Shrivastava, 2000, p. 31). Thus, either the “in” or “out” channels may differ, or both the “in” and out channels may differ from the trained task. Shrivastava (2000) used the term “channel cross” to describe the number of channels that differed from the training task. She probed adduction on one-channel cross and two-channel cross measures. The original training tasks were see/say phonemes and see/say non-words tasks. Adduction was assessed for a one-channel cross on hear/say spelling tasks in which only the “in” channel differed from the see/say training tasks. Adduction was probed on a two-channel cross task using hear/write spelling activities in which both the “in” and “out” channels differed from the see/say training tasks. Shrivastava (2000) hypothesized that greater adduction should be evident for a one-channel cross than for a two channel cross if learning in one channel is independent of learning in another channel as Lindsley (1994) suggested.

The findings of Shrivastava’s (2000) studies showed that for six of the seven learners adduction was greater across one learning channel than for two learning channels. However, the component rates of letter and word writing that were required for the hear/write two-channel cross adduction spelling tasks were not assessed prior to the intervention. Thus, low rates of the component skill of handwriting may have affected the lower rates on the probes for adduction across two learning channels. It may have been possible that the children involved in the studies could produce letter names orally during the tasks that assessed one-channel cross adduction at higher rates than written production of the letters during the two-channels cross adduction tasks. Thus, the higher rates on the probes assessing adduction across one learning channel may have been attributable to the higher rates of a component skill required for the composite skill performance. Therefore, this possible confounding of results may have limited the reliability of the conclusions drawn from this research.

The relationship between accuracy and rate

Researchers who have compared the effects of training to accuracy only criteria with training to rate criteria have demonstrated the advantage of the latter over the former (e.g., Shirley & Pennypacker, 1994; Bucklin, Dickinson & Brethower, 2000). Thus, it has been concluded in a number of studies that although accurate responding is important, it is the speed of responding that is the critical variable in producing superior results for particular learning outcomes. However, although there is agreement that fluent or proficient performance is characterized by a combination of accuracy and speed (Binder, 1996; Johnson & Layng, 1994; 1996), there is little uniformity in views concerning the instructional techniques for training accuracy within the context of rate-building procedures. A review of the literature revealed that there are conflicting recommendations regarding the most efficacious methods for including accuracy training in interventions aimed at improving response rates. For example, some researchers maintain that accurate responding should be trained before rate-building exercises commence. Howell and Howell (1990) asserted that students should not be involved in rate-building exercises until they can respond with 85% accuracy as otherwise they simply practise errors during rate-building. Other researchers have advocated training high levels of accuracy before attempting to increase response rates (e.g., Bucklin, Dickinson & Brethower, 2000; Williams, Haring, White, Rudsit & Cohen, 1990). Binder (1996) noted that White and Haring (1976), Haring (1977), and Haring and Liberty (1978) also described stages of learning that included acquisition (i.e., accuracy training), fluency-building (i.e., rate-building), maintenance, application, and adaptation.

In the Model of Generative Instruction proposed by Johnson and Layng and implemented at Morningside Academy (Johnson & Layng, 1992; 1994), phases of learning are also described. Learners pass through four phases of learning referred to as establishing, remembering, enduring, and applying. However, Johnson and Layng (1992; 1994) clarified that these learning phases can overlap and stated that "some learners could begin building fluency while still establishing their skills; others need to wait to build fluency until establishment is complete" (Johnson & Layng, 1994, p. 184). In the model, curriculum-based placement testing targets skills for each student. Then component-composite analysis facilitates the identification of the component elements for individual instructional objectives. Students work to establish (i.e., acquire) the component tool skills through accuracy training involving direct instruction. When accurate, they gradually increase their rates of the new component skills through rate building exercises known as "sprints". Sprints are very short durations of timed repeated practice (Binder, 1996; Johnson & Layng, 1994; Leach, 1996; Potts, Eshleman & Cooper, 1993). They can be as short as 10 seconds and are increased in increments to one-minute. The use of sprints reflects the application of research indicating that performance of non-fluent skills for longer periods than 10 to 20 seconds results in avoidance of the task and deterioration in rate and learning. During each practice session, numbers of correct and incorrect responses are recorded and charted to allow immediate analysis of performance frequency and learning rate.

The second stage of learning in the Generative Instruction Model (Johnson & Layng, 1992; 1994) is termed "remembering" and aims to ensure achievement of the retention outcome of the RESAA criteria. This phase comprises training of the component skill towards a frequency aim through rate-building exercises on one-minute drills. Students work and act as peer tutors whilst engaging in timed repeated practice over one-minute drills and self-record on celeration charts. Peer tutoring involves one student acting in turn as a tutor or coach to another student in the class.

When students achieve rate criteria in the remembering phase of the Generative Instruction Model (Johnson & Layng, 1992; 1994), they begin training in the "enduring" stage of learning. Worksheets and activities are extended and students are required to maintain the rate over extended periods of time. Johnson and Layng (1994) emphasize that the rate criteria usually, but not always, ensure skill endurance. Sometimes it is necessary for students to build higher rates of component skill performance to achieve the endurance outcome. At other times learners need to practice the skill over the expected time period required and build rates over these extended timings. This illustrates the dynamic nature of rate building for skill fluency and accentuates the idea that rate criteria are not static targets in themselves but are a means of working to achieve the learning outcomes depicted in the RESAA criteria.

The final phase of learning in the Generative Instruction Model requires students to apply the new component skills. Johnson and Layng (1996) have noted two types of application. Johnson and Layng (1996) consider application to have occurred when a learner can "easily apply the skill as a prerequisite or component of a more complex performance to be learned" (p. 285). Another form of application is referred to as "adduction" by Johnson and Layng (1996) and they consider adduction to have occurred when learners "demonstrate increasing capacity to learn new skills instantly, and on their own, as they move through a subject matter" (p. 285-286). Games, simulations, and arranged opportunities for the natural practice of composite skills (incidental teaching) provide a context for the demonstration of component skill application and adduction in the applying stage of learning in the Generative Instruction Model (Johnson & Layng, 1994). Thus, the model depicts an instructional design that can involve training accurate responding before building response rates or that can comprise the simultaneous training of accuracy and rate, depending on the individual learning characteristics of students. The model also implies a sequence whereby retention is attained before endurance, and endurance is achieved before application and adduction, although some learners may achieve some outcomes simultaneously as the learning phases may overlap, as noted previously. Binder (1996) also suggested that optimal performance rates for one of the learning outcomes, such as retention, may be different from optimal performance rates for another outcome, such as endurance. He encouraged further empirical research to investigate such relationships.

There are other researchers and practitioners who suggest that accuracy and rate can develop simultaneously. In fact, some have stated that an initial focus on accuracy can actually impede the rate-building process as students respond more slowly when they are fearful of making mistakes (Samuels, 1997; Lindsley, 1996a; Evans, Mercer & Evans, 1983; Haughton, 1972; Dowhower, 1987). Researchers assuming this standpoint often implement interventions in which some form of error correction method comprises an element in the rate-building procedure in order to allow accuracy to develop alongside rate (e.g., Peterson, Scott & Stroka, 1990). Binder (1996) asserted that errors are difficult to correct when a student's overall rates of responding are low but become much easier to correct when their rates exceed 50-60 responses per minute.

Some researchers have made reference to optimum accuracy levels of fluent performance whereby "fluency aims" are described in terms of both accuracy and speed (Scott, Wolking, Stoutimore & Harris, 1990; Mercer & Mercer, 1993; Meyer & Felton, 1999; Howell & Morehead, 1987; Carnine, Silbert & Kameenui, 1990). For example, Alper, Nowlin, Lemoine, Perine and Bettencourt (1974) specified a proficiency rate for see/say sounds for children from kindergarten to Grade 3 of 80 per minute with 0-2 errors. These authors have not necessarily stipulated whether accuracy should be trained before rate but agree that fluency aims should comprise descriptions of both the speed and accuracy of performance. Other researchers and practitioners only include descriptions of the speed of responding in rate criteria (e.g., Aulls, 1978; McDowell & Keenan, 2001). Even when researchers and practitioners agree that accuracy levels should be included in statements of performance aims, there is little consistency in suggestions of acceptable levels of accuracy. For example, Scott et al. (1990) used an 83% accuracy criterion before rate-building commenced in their study. Howell and Morehead (1987) suggested a rate of 80-140 words per minute with 95% accuracy as criteria for acceptable performance of passage reading. Mercer and Mercer (1993) were of the opinion that accuracy levels of 90-100% must be attained with speed to indicate proficient performance.

The opposing views in the literature concerning the relationship between accuracy and rate development have resulted in a lack of guidelines for implementing rate-building procedures. Research that directly compares the effects of training accuracy before rate with training accuracy and rate in a simultaneous interactive approach is clearly required. Results may indicate that one training method is more efficient than the other and could provide some useful guidelines for planning instructional procedures aimed at increasing response rates in children.

Research relating to rate-building and the RESAA criteria

Empirical evidence for the effects of rate-building procedures on all of the learning outcomes depicted RESAA is very sparse. Although some experimental studies have demonstrated improved learning outcomes after the implementation of rate-building procedures (Doughty, Chase & O'Shields, 2004; Kuhn & Stahl, 2003), these studies generally have assessed the effects on only one learning outcome, such as retention (Ivarie, 1986; Shirley & Pennypacker, 1994) or endurance (McDowell & Keenan, 2001). The operationalization of fluent performance standards in terms of the RESAA measures and the specification of response rates that ensure the achievement of all of these standards is relatively rare. Also, most of the empirical studies of rate-building procedures have not controlled for the effects of practice and reinforcement and, thus, it is impossible to attribute the positive results in many of these studies to the effects of building response speeds, rather than to increased opportunities for practice or reinforcement (Doughty, Chase & O'Shields, 2004; Kuhn & Stahl, 2003).

Bucklin, Dickinson, and Brethower (2000) compared the effects of rate building and accuracy training on application and retention of a visual association skill. Twenty-nine college students participated in the study. To assess application, the researchers trained two unrelated component tasks and then had the participants complete a third task that required the component tasks but was not directly trained. The component tasks were see Hebrew symbol-write nonsense syllable and see nonsense syllable-write Arabic numeral tasks. Application was assessed on a composite task involving Hebrew symbols written as arithmetic problems and asking participants to write the answers in

Arabic numerals. An accuracy only group was trained to a 100% accuracy criterion and then were given no further training. Bucklin et al. (2000) assessed the rates of each component skill after the participants had reached the accuracy criterion "to ensure that fluency had not developed" (p. 151). The researchers used "fluency criteria" of 40 and 70 correct responses per minute for the see Hebrew Symbol-write nonsense symbol and the see nonsense symbol-write Arabic numeral tasks, respectively, during these assessments. Bucklin et al. (2000) stated that "none of the trainees were fluent according to these criteria" (p. 151). However, they provided no support for the use of these criteria and there were no additional measures to indicate that these "fluency criteria" would, in fact, ensure fluent performance. The remaining participants, in the "fluency group", were first trained to the accuracy criterion and then trained to "fluency criteria" of 50 or more correct responses per minute for the Hebrew symbol-nonsense symbol task and 100 or more correct responses per minute for the Nonsense syllable-Arabic Numeral association. The researchers did not provide support for the specification of these performance rates. In addition, these "fluency criteria" were different from the criteria used to ensure that the accuracy-trained group had not developed "fluency", which was very confusing. Composite and component skill retention was assessed every two or four weeks for sixteen weeks after the completion of the intervention.

The results of Bucklin, Dickinson and Brethower's (2000) study demonstrated that the "fluency group" achieved almost double the number of correct responses per minute on the application task than the accuracy trained group on the immediate post-tests. Moreover, the difference between the groups was statistically highly significant ($t = 5.39$, $df = 28$, $p < 0.00001$). The researchers asserted that their data supported the claim that fluency in component skills leads to fluency in composite skills and that the acquisition of the higher level skills were eased by fluent component skills. Loss of "fluency" was measured on longer-term retention tests. The fluency group showed the least losses in rate on the composite task both from the post-tests to the first retention test and from the post-tests to the final retention tests. Overall, the rate-trained group retained a high level of accuracy across the four-month retention test period, whilst the participants trained to accuracy only lost considerable accuracy after only four weeks. However, these researchers did not control for the quantity of practice in the two conditions. Only the fluency group in the Bucklin et al. (2000) study was involved in additional practice of the component tasks. In this case, the improved results of the rate-trained group may have been the consequence of increased practice alone, rather than effect of increases in response rates.

The terminology used by Bucklin et al. (2000) again highlights the inconsistencies in the rate-building literature. The researchers used the term "fluency criteria" to describe performance rate aims and "fluency training" to describe rate building of the skills. However, there was no operational definition of fluency nor measurements to indicate that the arbitrary rate criteria used would optimize the learning outcomes that are characteristic of fluent performance. Thus, the researchers actually investigated the effects of attaining specific rate aims of component skills on retention and application, and they made unsubstantiated claims concerning the achievement of fluency. Thus, the misconception described by Binder (2004) that fluency is a separate dimension of behaviour that then produces learning outcomes, such as retention and application, was exemplified in Bucklin et al.'s (2000) article.

Chiesa and Roberts (2000) demonstrated improved skill application after building rates of component maths skills. The study was conducted over twelve weeks and included five children aged nine to ten years. These five children were identified by the classroom teacher as in need of remedial support in mathematics. The composite skill targeted for improvement was division calculations of two digit numbers by one digit divisors up to five with remainders. The researchers performed a task analysis of composite skill and listed the component skills to be trained. They considered a "satisfactory level of performance" (p. 303) to be 40 to 50 responses per minute but did not indicate any support for using this response rate rage. Some of the component skills were number writing and saying multiplication tables. All of the children in the class, including the five participants in the study, were assessed before the commencement of the intervention on their correct and incorrect rates of division calculations. The children were assessed again on the same skill after the intervention had been completed with the five participants.

The results of Chiesa and Robertson's (2000) study showed that the five children targeted for intervention initially performed the lowest correct rates of the composite skills compared to all of the children in the class. The post-tests, however, indicated that the five children outperformed all but one of the children in the class after participating in the rate-building exercises for 30 minutes each week for twelve weeks. The five children showed an increase from a mean of one response per minute on the composite skill pre-tests to 13.2 per minute on the post-tests compared to an increase from 3.7 per minute to 4.2 per minute for other children in the class. A significant difference between the experimental and control groups was found on the division problems after the implementation of the intervention (t = 5.49, two-tailed test, p <

0.001). Although these results demonstrated improved performance after rate-building of component skills for the five participants, Chiesa and Robertson (2000) did not control for practice effects. Therefore, again the results may have been the consequence of increased practice of the skills by the five participants, rather than the consequence of increased response rates alone.

McDowell and Keenan (2001) conducted a study which aimed to examine the effects of "different levels of skill fluency" (p. 345) on task endurance of a nine-year old boy who had a diagnosis of Attention Deficit Hyperactivity Disorder. However, the researchers appear to have made the common misinterpretation of the term of "fluency", noted by Binder (2004) and described earlier in this chapter, by referring to "fluency" as a separate dimension of behaviour that occurs before, influencing skill endurance. McDowell and Keenan (2001) would have been more accurate in stating that they aimed to examine the effects of different <u>response rates</u> on skill endurance, a learning outcome that is characteristic of fluent performance.

The dependent variables in McDowell and Keenan's (2001) study were the number of letter sounds read correctly per minute from printed cards and the time spent on-task. Time spent on-task was defined as the time spent engaged in sounding letters. McDowell and Keenan (2001) stated that any "other behaviour that occurred while the timer was running was regarded as time spent off task" (p. 346). However, it would have been possible for the children to display other behaviours at the same time as performing the see/say task, such as standing up or tapping on the desk. It was not clear whether these behaviours would be scored as off-task if they occurred at the same time as the child performed the see/say task. The researchers collected data on the dependent variables for each minute of four 10-minute sessions during baseline. The highest one-minute score was reported. Practice sessions followed in which the child was taught to read the sounds with 100% accuracy. Data were then collected during the one-minute timings in the proceeding intervention sessions in the same manner as at baseline. Reinforcement for the participant was contingent upon him matching or beating the previous sessions' score. The performance aim was set at 60-80 sounds per minute based on the performance standards suggested by the Great Falls Precision Teaching Project. Once the "fluency goal" (p. 346) was reached, reinforcement was contingent on maintenance of this goal level. Three reversal sessions were conducted whilst the child was at "mid-fluency" (p. 346), which was not defined, and four were conducted at the "fluency goal" (p. 346) when the child attained a rate of between 60 and 80 sounds per minute.

The results of McDowell & Keenan's (2001) study indicated that at baseline the child displayed low rates of correct see/say phonemes and incorrect see/say phonemes occurred at a slightly higher rate. He spent an average of only 50% on-task during the baseline sessions. The intervention produced an immediate increase in correct responses and a decrease in incorrect responses and he remained on-task for 100% of these sessions. The researchers contended that these results were consistent with Binder et al.'s (1995) reports that "increases in fluency were accompanied by increased on-task endurance" (McDowell & Keenan, 2001, p. 348). The researchers also stated that the "reversals before responding had reached fluency resulted in decreases in correct responding" and only 50 – 60% of the time was spent on-task, but that after "repeated exposure to the intervention, the child's performance remained fluent and endurance improved during the third reversal to baseline" (McDowell & Keenan, 2001, p. 348). Again the term "fluency" was inaccurately referred to as a separate dimension of behaviour that occurred before endurance. These results actually showed that increases in response rates produced improved skill endurance, which is a characteristic of fluent performance and that, after repeated exposure to the intervention, the child's response rates had increased to levels that were more likely to predict skill endurance than the lower response rates he was attaining at the time of the baseline reversals. The results did not specifically show that his performance "remained fluent".

Although McDowell and Keenan (2001) claimed to investigate endurance, the conceptualization of skill endurance also appeared inaccurate in the study. In most related literature endurance is defined as performance of the skill at the target rate for intervals of time that are longer than the durations used during practice (Johnson & Layng, 1996, 1992; Binder, 1996). According to this definition, it would be impossible to assess endurance without extending the performance timings. However, all of the timings in the McDowell & Keenan (2001) study were one-minute durations and there were no increases in the length of the timing intervals. Rather, the researchers used a measure of on-task behaviour to indicate endurance levels. Furthermore, the only difference between the one-minute intervention timings and the one-minute baseline reversal timings appeared to be the availability of reinforcement after the former timings and non-availability of reinforcement after the latter timings. Thus, the decreases in correct see/say phoneme rates during the reversal phase at "mid-fluency" may have been partially attributable to the withdrawal of reinforcement, rather to insufficient response rates alone.

McDowell and Keenan (2001) used the term "fluency goal" to indicate the target rate of performance. However, as in other studies, such as in Bucklin, Dickinson and Brethower's (2000) study, it was not at all clear that this rate of responding would ensure “fluency”. In fact, 60-80 sounds per minute might be considered a non-fluent rate by other researchers and practitioners (Johnson & Layng, 1994; Binder, 1996; Haughton, 1972). They also used the terms “mid-fluency level” and “fluency level” to indicate periods in which they probed endurance. However, other than the numbers they assigned to indicate these levels, there was no empirical evidence that the participant was see/saying sounds at “mid-fluency” or “fluently”. Again there appeared to be misuse of such terms.

Binder, Haughton and Van Eyk (1990) described an unpublished research project that demonstrated the effects of high response rates on endurance. The project took place in Hastings County, Ontario, and involved 75 kindergarten through eighth grade students. The participants practiced writing digits from zero to nine as quickly as possible. The length of the practice interval was changed on different days from 15 seconds, to 30 seconds, to 1 minute, to 4 minutes, to eight minutes and to 16 minutes. The researchers found that the students who could write digits at 70 per minute or above on the 15-second timings could perform at almost the same rate on the 16-minute timings. However, those children who wrote digits below this rate showed rapid declines in rate as the length of the timings increased. Students who wrote at below 20 per minute on the 15-second timings actually ceased to write before the 16-minute intervals were completed. Thus, higher rates were necessary to ensure skill endurance over longer intervals than during training. Nevertheless, the research was not described thoroughly by Binder, Haughton and Van Eyk (1990) and it was difficult to ascertain whether the studies were conducted under entirely controlled experimental conditions as it was the classroom teachers who implemented the intervention.

A common problem in the studies reviewed so far and in most other research involving rate-building procedures is the lack of control for reinforcement and practice effects. For example, Doughty, Chase and O'Shields (2004) recently published a thorough literature review on "the effects of rate-building on fluent performance". They reviewed 48 articles that were obtained through a comprehensive search of the PSYCInfo psychological research and the ERIC EBSCO Host educational databases, through communication with precision teachers and educators, and through reference lists of articles already obtained. They concluded that there was very little empirical evidence that rate-building procedures produced increased retention, persistence and generalization when the effects of practice and reinforcement were controlled. Similarly, an article by Kuhn and Stahl (2003) reviewed theory and research regarding "fluency instruction" and development. They concluded that although the rate-building instructional procedures were effective, it was unclear whether improved outcomes were the result of specific aspects of the procedures or whether the improvements were the result of increased repeated practice. Thus, it is impossible to conclude from many empirical studies involving rate-building procedures that it was in fact the speed of responding that produced improved results, rather than increased practice or reinforcement during rate-building interventions.

An unpublished doctoral study did assess the effects of rate-building on each of the RESAA outcomes and controlled for the effects of practice. Shrivastava (2000) compared training in a freer-rate building condition with training in a constrained-rate condition, and the numbers of practice repetitions were matched in two conditions. The project consisted of two studies. The first involved four children in Grade 1 who were identified as having reading ages closest to their chronological ages on the Test of Early

Reading Ability (Reid, Hresko, & Hammill, 1981; in Shrivastava, 2000). These children were taught to see/say phonemes represented by individual letters under both conditions. The second study included three children aged between 10 years 1 month and 12 years 3 months. One of these children had a reading age that was close to her chronological age whilst the other two children had much lower reading scores in relation to their chronological ages. Thus, the latter two children represented students with significant reading problems. The three children in the second study were trained to read three-letter nonsense words in both conditions. Shrivastava (2000) measured response rates during a baseline phase and on post-tests in both conditions. Response rates were also assessed throughout the intervention phase in the free-rate condition only. RESAA measures were taken during the baseline phase and on post-tests. The retention tests were conducted after two weeks of no practice. The results of the studies indicated that the freer-rate condition produced higher response rates than the constrained-rate condition for all seven learners and, in addition, there was greater evidence of retention, endurance, stability, application and adduction for each of the students. As Shrivastava (2000) controlled for practice effects it was possible to conclude that the superior performances on the RESAA measures of the participants in the freer-rate condition were the consequence of increased response speeds during training, rather than to the effects of greater quantities of practice.

Shrivastava’s (2000) studies demonstrated empirical evidence for the efficacy of rate-building procedures compared to constrained-rate discrete trials methods in improving performance on the RESAA measures. However, the see/say response rates that were achieved during training were only probed throughout the intervention phase in the rate-building condition, and were not assessed in the constrained-rate condition.

Although Shrivastava (2000) did probe application and adduction throughout the intervention phase in both conditions, the lack of see/say rate probes in the constrained-rate condition did not allow the effects of specific response rates on application and adduction to be assessed. Binder (2004) emphasized that a failure to probe response rates following constrained-rate procedures “leaves out an essential piece of the puzzle” (p. 285). He maintained that it is essential when comparing self-paced and controlled trials:

> “to probe freely emitted response rates after the controlled trials conditions and before tests for learning outcomes such as retention and application to compare the immediate and direct impact of each procedure on response strength, using Skinner’s measure” (Binder, 2004, p. 285).

Shrivastava (2000) did not probe retention, endurance or stability during the intervention phase in either condition. Rather, only pre-test and post-test measures of these outcomes were conducted. Thus, it was only possible to compare the effects of the final see/say rates produced in the two conditions on these performance measures. Binder (2004) also noted that “the most common error in graduate students’ experimental design for fluency research is the failure to include response-rate probes at all appropriate points in a sequence of procedures” (p. 286).

Another limitation of Shrivastava’s (2000) study comprised the length of the timings used to measure see/say response rates and RESAA rates. The participants’ rates were assessed on 30-second probes for all but the endurance measures. Shrivastava (2000) then converted these rates to per minute rates by doubling them. Although this procedure would give approximate rate measures over one minute, the actual performance rates of the children over one minute were not assessed. It is possible that the children's initial speeds of responding may have decelerated over timing intervals. Thus, the doubling of the rates obtained on the 30-second timings may have inflated per minute rates above the levels that would actually be attained on one-minute timings. In contrast, building the children's rates over drills of increasing length to one minute, and then using one-minute probes, would provide more accurate measures of actual performance. The endurance probes were the only measures conducted on one-minute timings.

Shrivastava (2000) overcame the limitation in many studies relating to the lack of control for practice effects but there were no controls for the quantities of reinforcement in each condition. Therefore, greater quantities of reinforcer presentations in the rate-building condition may have partially accounted for the improved results. Although the research conducted by Shrivastava (2000) produced promising results that indicated the speed of responding was the critical variable that produced superior results compared to constrained-rate repeated practice, there were only a small number of participants included in each study. Therefore, further research of this kind is warranted. The retention period of only two weeks was also very short and the effects of building response speeds on retention over longer intervals of no practice are required.

Bonser (2002) also conducted a series of studies in his unpublished doctoral thesis that aimed to investigate the effects of attaining particular response rates on the RESAA measures with children with autism. In the six experiments, Bonser (2002) targeted a number of component skills for intervention, including gross motor imitation, pre-writing tracing skills, single-digit addition sums of less than five, and single see/say phonemes, with children with autism, and answers to general knowledge questions with

Grade 6 children without autism. Like Shrivastava (2000), Bonser (2002) also compared controlled-rate and free-rate procedures in his sixth study and aimed to control for practice and reinforcement effects. However, in contrast to Shrivastava's (2000) results, he concluded that the speed of repeated practice was <u>not</u> a significant variable in improving performance on some of the RESAA measures, compared to constrained-rate repeated practice. In this study, Bonser (2002) targeted a "see general knowledge questions/say the answers skill" using SAFMEDS with five Grade 6 children from mainstream classrooms (Bonser, 2002). Application to a hear/say task was probed during pre-intervention assessments and post-intervention assessments. Pre-tests and post-tests of see/say rates in the presence of music, played on a radio, were also included. Although not stated by Bonser (2002), it can be assumed that this was a measure of skill stability. Each child was allocated 20 questions, which were printed on cards. Ten of these questions were taught under controlled-rate conditions and the other ten were taught under "free-rate" conditions. Rate aims and overlearning criteria were selected "to represent the range of frequencies or overlearning trials thought to predict fluent performance based on an adult's performance of the task" (Bonser, 2002, p. 186). However, Bonser (2002) did not provide details to describe the measurement of the "fluent performance" of the adult. Thus, it was unclear how the performance of the adult was considered fluent, and that the performance rates used in the study would, in fact, predict fluent performance outcomes. Bonser (2002) provided rate aims for three participants and no overlearning aims were specified for these children. For the remaining two individuals, overlearning aims were specified but no rate aims were set. Rate aims of 70 per minute on three consecutive intervals were used for two of the children and an aim of 100 per minute on four consecutive trials were used for another child. For the other two children, overlearning aims of 100% on 10 intervals and 100% on eight intervals were set respectively.

The intervention in Bonser's (2002) study was conducted within an alternating treatments design. Equal quantities of questions were presented in each of the treatments conditions to control for practice effects. During the self-paced learning procedure, the children were required to say the answers to questions as quickly as possible. During controlled-trials training, a signal to move to the next question was given to the children every six seconds. A timer was set to count up in each condition. The children continued responding in the free-rate condition until they had completed all ten cards and the timer was stopped and the time taken was noted. Alternatively, the children were told to stop if the timer reached 20-seconds, even if the children had not completed the ten questions, and the numbers of correct and incorrect responses were noted. Bonser (2002) does not explain the reasoning for using 20-second intervals and does not explain how or whether these rates were converted to per minute rates. In the controlled-rate condition, the timer seemed to be used to measure intervals of six seconds to allow the researcher to signal to the participants when to move to the next question. Bonser (2002) also claimed to have equated quantities of reinforcement in the two conditions. However, he described reinforcement that was contingent upon beating previous scores in both conditions. It is unclear how reinforcement was, therefore, equal in the two conditions as differences in the participants' performances between conditions may have resulted in different frequencies and quantities of reinforcement.

Bonser (2002) reported results that showed that errors were eliminated more quickly in the controlled-rate condition compared to in the free-rate condition and that time-controlled training aims were attained in fewer intervals than the frequency aims.

However, it is unlikely that the children had attained similar levels of competency when they had reached the time-controlled aims compared to when they had first attained the frequency aims. Thus, these findings simply indicated that the time-controlled aims were more attainable than the frequency aims within a similar time period, but revealed little about the competency of performances. The post-test phase showed that hear/say rates on the application probes, and see/say rates with music were very similar in both conditions. One-month and three-month retention probes also indicated similar results in the two conditions. Bonser (2002) concluded that the speed of practice did not "determine whether the children developed fluency or not" (p. 202). However, as Binder (2004) noted, simply shifting from rate-controlled trials procedures to procedures and materials that allow students to respond as quickly as they are able can have the effects of doubling, or even tripling, response rates without any other intervention. This effect was in fact observed in Bonser's (2002) study. When the children's response rates were assessed on the post-test measures, the tests allowed freer-rate responding. The children's response rates for the set of questions allocated to the controlled-rate condition increased dramatically from the controlled rate of 10 per minute, during the intervention phase, to rates similar to those attained in the free-rate condition of almost 100 per minute in the post-test phase. Thus, the similar see/say training rates that were attained in the two conditions accounted for the similar effects on measures of retention, stability and application. The findings did show that the speed of practice did not determine the levels of <u>training rates</u> attained, but they also showed that the similar see-say rates attained produced similar effects on the learning outcome measures, regardless of the technique by which the training rates were achieved. The claim by Bonser (2002) that the speed of practice did not determine the attainment of “fluency” was unsubstantiated.

Binder (2004) suggested that rather than comparing the effects of controlled trials with the effects of self-paced practice on learning outcomes, such as retention and application, a more interesting approach in framing rate-building research might be to investigate whether the rate of “freely emitted responding” (p. 282) better predicts learning outcomes regardless of whether that rate is produced by controlled-trials practice, self-paced practice or a combination of both. Thus, Binder (2004) encouraged research that examines the utility of rate of response as a measure for predicting the learning outcomes, rather than research that aims to investigate the effects of free-operant and constrained-operant procedures on the learning outcomes. Binder (2004) goes on to pose the question: “Does it [rate] tell us more than percentage correct?” (p. 282). The results of Bonser’s (2002) study suggest a positive answer to this question, as the imposed ceiling of 100% accuracy at a rate of 10 per minute allowed no observations of further achievement beyond this criterion. In contrast, the shift to rate of response measures during the post-test phase indicated much higher degrees of skill competence, evidenced by the rapid increase in correct training rates, compared to the accuracy only measures. Thus, studies that include ‘free-rate’ measures after controlled-rate procedures are required to more accurately compare the effectiveness of accuracy only measures to rate measures, and to assess the utility of response rate measures in predicting the RESAA outcomes, regardless of the method by which these rates are produced.

Some of the other studies conducted by Bonser (2002) also have relevance to the current research project. The effects of specified response rates on the RESAA outcomes were reported to be the focus of Bonser's (2002) research. However, the descriptions of the order of the procedures used and the data reports were often unclear, and there were a number of significant limitations concerning measurement of the RESAA outcomes in the research.

In Bonser's (2002) first study, he taught two children with autism to imitate a set of ten gross motor movements, such as clapping and waving, through modelling and discrete trial training to 100% accuracy on three consecutive trials. Application probes were then conducted that measured generalized imitation to topographically similar movements, such as tapping the shoulders or the head, and to topographically dissimilar movements, such as drawing straight lines and circles. Bonser (2002) did not indicate which of the application sets presented in his thesis were designed to be topographically similar or dissimilar to the trained gross motor movements but it would seem that these are examples of the two movement forms from the sets listed in the Bonser (2002) study. The application probes measured percentage correct scores on eleven sets comprising four to 20 gross and fine motor movements. Bonser (2002) reported slight increases in trained gross motor imitation rates to 17 per minute and six per minute after discrete trial training. He also reported improvements on seven application sets, with median scores ranging from 0% to 40% correct across the sets.

Following the discrete trials training in Study 1, Bonser (2002) then set a rate aim of 60-70 movements per minute, based on the assessed rates of a competent adult, and the children's gross motor movement rates were trained over 10-second intervals. The order of procedures described in the remainder of this study, and the data reported, are unclear after this point. This lack of clarity, unfortunately, limited understanding of the methods used and the results obtained in the study. For example, Bonser (2002) reported that the 10-second practice intervals increased gross motor imitation rates for the boy “Adrian” from 42 per minute to 102 per minute, even though he had reported a rate of 17 per minute for this child from the previous phase. Similarly, he described increases in gross motor imitation rates for “Simon” from 12 per minute to 84 per minute but had reported a rate of six per minute from the pervious phase. The graphs suggested he was perhaps referring to increases within the frequency-building phase. He then stated that application probes were again scheduled after the children had achieved the frequency aims. Improvements on all sets, except a fine motor drawing imitation set, were reported for both children and median scores on the improved sets ranged from 20% to 100%. From these results, Bonser (2002) concluded that a rate aim of 70 gross motor movements per minute was sufficient to achieve significant generalized imitation for both children. However, he reported the attainment of rates of 102 per minute and 84 per minute for each child. Therefore, the improvements in the application scores were more likely to reflect the effects of these rates and not rates of 70 per minute. The statement also seems an overgeneralization considering most of the median scores for the children across the application sets, at this point, were within a range of only 0% to 60% for eight of the 11 sets for one child and for six of the 11 sets for the other child. The title for the table that displayed these results stated that the data related to the six sets of application probes, but there were 11 sets listed in the table. Thus, interpretation of the results is limited.

Some of the conclusions drawn by Bonser (2002) from his first study, however, are relevant to the current research. Bonser (2002) concluded that children were able to maintain their rates over longer intervals, indicating endurance. However, the children’s rates of gross motor imitation were trained over increasing time intervals of

10, 20, 40, and 60 seconds for the remainder of the frequency-building phase after they had reached the frequency aim. Thus, endurance was not specifically assessed during this period, but was explicitly trained. Retention probes were conducted after a four-week period of no intervention and the children were reported to have maintained their rates and actually showed improvements on some of the application measures. However, these improvements could only refer to performance on four of the eleven application sets, as 100% accuracy was reported for the other sets before the retention period. Thus, the use of percentage correct scores only for the application probes rendered it impossible to ascertain any improvements for the sets on which the children had already attained the ceiling score of 100%. Bonser (2002) also included a 120-second probe after the four-week period of no intervention, presumably to assess endurance, and reported that the children showed decreases in gross motor imitation rates from 100 to 75 per minute and from 75 to 60 per minute respectively. He stated that although the rates decreased, these rates were relatively high. However, he does not refer to the 120-second probes when summarizing the findings. He stated that:

> "at this point both children's motor imitation skills had demonstrated most aspects of the RESAA criteria. They had demonstrated that they were able to maintain the same rate after a period of no practice, they were able to perform the skill at the same rate over both short (10-s) and long (60-sec) intervals, and the initial adduction and subsequent generalised imitation to new movements in the application probes (i.e., adduction of components to form composite repertoires)" (p. 75).

This was the first reference to adduction in the study. It was not clearly defined nor were measurements of adduction clearly described. Perhaps Bonser (2002) intended to use the sets comprising topographically dissimilar movements as adduction measures. However, no clear differentiation was made between application and adduction.

In Bonser's (2002) second study he investigated the effects of increasing the rates at which two children with autism traced tally slashes on two forms of application tasks. One task involved tracing other pre-writing shapes (like circles), letters and numbers. The second task required the children to copy lower case and upper case letters and numbers. Application measures were rate-based in this study. The participants' response rates were increased through similar procedures as those employed in Bonser's (2002) first study and involved 10-second practice intervals. A "fluency aim" of 100 per minute was set, based on the assessed rate of a competent adult. Bonser (2002) also scheduled application probes when the participants reached rates of 60 per minute and 80 per minute. These rates were chosen arbitrarily to "provide snapshots of a skill developing fluency" (Bonser, 2002, p. 97).

The results of Bonser's (2002) second study showed that on the first set of application probes, when both children's training rates reached 60 per minute on Day 5, concurrent increases in rates on the tracing application tasks were observed. However, the children's rates on the copying application task remained at zero. The increase in practice intervals from 10-second to 30-second practice intervals, after these probes were conducted, resulted in decreases in correct rates for both children. The reimplementation of 10-second practice intervals produced increases in the children's rates to 84 per minute and 90 per minute respectively. The 30-second intervals were re-introduced and, although both of the children's rates decreased, they increased after a number of days and the children achieved the 80 per minute aim on the 30-second practice intervals. The application probes showed greater increases in rates on the tracing application tasks but the rates on the copying application tasks remained at zero. The rate-building that followed involved 60-second practice intervals for one of the children (Mark) and 30-second training timings for the other child (Justin). "Mark" reached an aim of 118 per minute and Justin attained a rate of 100 per minute. "Justin's" rate was then assessed on a 60-second probe and his rate maintained over this timing. Both of the children were then assessed under baseline conditions involving 60-second probes and the rates were maintained at or above 100 per minute. Bonser (2002) concluded that these results showed skill endurance. However, only "Justin" was tested on a longer interval than those involved in training. Thus, skill endurance after the attainment of rates of over 100 per minute was demonstrated for <u>one</u> child, but endurance was <u>trained</u> for "Mark". The application probes indicated similar tracing rates as the previous probes and copying rates remained at zero. Bonser (2002) concluded that application occurred before endurance. He stated that measures of application "peaked" when the target behaviour rates reached or exceeded 80 per minute. He concluded that these data indicated when tracing "had become fluent enough to allow for clear application of tracing skills…However, to achieve skill endurance further practice was required and happened only when both children reached 100 per minute" (Bonser, 2002, p. 111). In these statements, Bonser (2002) has also made the mistake of referring to "fluency" as a temporal behavioural dimension that, when achieved, produced application and endurance. However, the effects of different training rates on skill application and endurance, and not different levels of fluency, were investigated in the study and, thus, the conclusions relating to fluency are unsupported. Only two children were included in the study and, therefore, further research involving more participants is required to investigate whether application occurs before endurance. Bonser (2002) also concluded that increasing the rates at which the children traced tally slashes was insufficient to promote “adductions and application to freehand copying skills” (p. 111). Again Bonser (2002) did not clearly differentiate application and adduction measures in this study.

In his fifth study, Bonser (2002) investigated the effects of the attainment of increased see/say phoneme rates on application probes involving see/say words containing the target phonemes and see/say words containing non-trained phonemes. See/say phoneme rates were trained to 60 to 80 per minute based on suggestions by Maloney (1998; in Bonser, 2002). Rates were trained on 10-second practice intervals. When both of the children achieved the rate aim, the application probes were administered. There were small improvements in see/say words for two-letter words but no improvements for three-letter words containing targeted phonemes and for those comprised of phonemes not targeted in the intervention. Endurance was then assessed over one minute and both of the children’s rates decreased. Further frequency-training to rates of 100 per minute for one child and 70 per minute for the other produced increases in the number of two-letter and three-letter words read correctly per minute that contained the target phonemes. There were no improvements in the rates of see/say words containing phonemes not targeted in the intervention. Rates were then assessed after a one-month period of no practice. See/say phoneme rates and application rates for the words containing the target phonemes were maintained. There were no improvements in see/say rates for the words containing phonemes not targeted in the intervention. Bonser (2002) confirmed his prediction that adductions would only occur with words containing the target phonemes. He also claimed that this study, and the previous four studies, indicated that the children demonstrated skill stability. However, there were no defined measurements of stability and no distractions were included in any of these studies. Only in his sixth study did Bonser (2002) include a testing condition in the presence of a distraction in the form of music, played on a radio.

The conflicting evidence in the Bonser (2002) and Shrivastava (2000) studies concerning whether speed was the critical variable in rate-building procedures that produced superior results on the RESAA measures compared to constrained-rate repeated practice highlights the requirement for further investigation. Also, the limitations that were noted for each study indicate that additional research into the effects of specific rates of responding on the RESAA measures is needed. There was also conflicting evidence concerning rates that predicted particular RESAA outcomes.

Large-scale demonstrations of rate-building procedures

Some of the most impressive results concerning behavioural fluency have been produced at the Morningside Academy in Seattle, Washington and at the Malcolm X College in Chicago, Illinois (Johnson & Layng, 1992; 1994; Johnson, 1991; Binder, 1991). These schools provide instruction in academic skills for children and adults. The curriculum follows the Generative Instruction and Fluency model which was described in detail in this chapter on pages 36 to 38. The model fundamentally incorporates precision placement testing, Direct Instruction, rate-building in component tool skills, and the use of the standard celeration chart (Johnson & Layng, 1992; Johnson, 1991). Principles from at least four sources of instructional technology are incorporated in the Morningside program, including the Personalized System of Instruction, Direct Instruction, Precision Teaching, and instructional design procedures proposed by Tiemann and Markle (Binder, 1991). Progression through curricula is based on the achievement of rates that meet functional criteria which ensure learning outcomes as summarized in the REAPS (and later RESAA) criteria.

Johnson & Layng (1992) state that at Morningside Academy "children diagnosed as learning disabled, who have never gained more than half a year in any one academic year, typically gain between two and three years in each academic skill per year" (p. 1482). Moreover, they offer two money back guarantees. One guarantee assures that a child who is two or more grade levels behind will gain at least two grade levels in one year in literacy and mathematics. The other guarantee maintains that children diagnosed with ADHD will increase their on-task behaviour from the typical one to three minutes to 20 minutes or more. Johnson and Layng (1992; 1994) provided the mean standardized achievement test grade level gains achieved by the students at Morningside Academy from kindergarten to eighth grade for 12 month periods over 12 years. The Metropolitan Achievement Test (MAT6) and the California Achievement Tests were the standardized measures used. In each twelve month period for the years from 1981 to 1992 the mean grade level achievements ranged from 2 years to 2.8 years for reading, from 1.6 years to 3.9 years for language arts, and from 1.9 years to 3.9 years for mathematics (Johnson & Layng, 1992; 1994).

An adult literacy and numeracy program was created at Morningside Academy, in 1987 (Johnson and Layng, 1992). Morningside agreed to be paid for only those students who advanced at least two grade levels in two skills. The first project involved 32 African-American males, aged between 16 and 26 years, over a period of 21 months. These students entered the programs with skills that were measured on the MAT6 to be between second grade and eighth grade. Each individual attended Morningside from Monday to Friday between 1 p.m. and 3 p.m. Out of the 32 students, 29 attained skills that were at or above the national eighth-grade level literacy standard. They progressed at an average rate of 1.7 grades per month (or per 20 hours of instruction) in each skill with an average attendance of 3.8 days per week. Similar results were demonstrated 13 months later with a group of 20 Asian-American women aged between 25 and 40 years. They entered the program with skills in mathematics, reading, spelling and writing that were between fifth and eighth grade levels. Nineteen of these 20 students exited the program with skill levels that were necessary for successful entry into their occupational skills training program with a mean attendance rate of 3.9 days per week. These students progressed at an average mean rate of 2 grades per 19 hours of instruction. These impressive results clearly highlighted the effectiveness of the Morningside program, of which rate-building procedures are a fundamental element, in comparison to the guideline provided by the US government of 100 hours of instruction for one year's growth (Johnson, 1991). Johnson (1991) stated that he and his colleagues were unable to locate any evidence in the adult education literature that showed faster growth in literacy programs than the improvements demonstrated by the students at Morningside Academy.

Research evidence obtained from other fields of study

Descriptions of education and training rate-based procedures often include reference to research on overlearning and automaticity (Binder, 1996; Johnson & Layng, 1992; Doughty, Chase & O'Shields, 2004; Chard, Vaughn & Tyler, 2002; Kuhn & Stahl, 2003; Raskinski, Linek, Sturtevant & Padak, 1994). Evidence to indicate associations between component skill rates and subsequent achievement on more complex composite tasks can also be found in reading research literature. Some of the most important and relevant literature from other fields of study that is related to the current research is reviewed in the following sections.

Overlearning and automaticity

Overlearning is a strategy derived from cognitive theories of memory that describe repeated practice on additional learning trials beyond an acquisition criterion of 100% accuracy (Driskell, Willis & Cooper, 1992; Binder, 1996). Repeated practice is the underlying principle common to both overlearning and rate-building procedures. However, the difference between overlearning and rate-building techniques is the time component. In rate-building exercises students are involved in repeated practice and overlearning, but training involves timed performance and the major aim is to improve the speed of accurate responses.

The effectiveness of overlearning in enhancing learning has been acknowledged by researchers for many years (Postman, 1962; Casey, 1975; Driskell, Willis & Cooper, 1992; Schendel & Hagman, 1982). For example, Driskell et al. (1992) conducted a meta-analysis that included studies examining the effect of overlearning on retention. A thorough search yielded 15 studies for inclusion in the analysis. The results revealed that the combined effects of the 88 hypothesis tests were of moderate magnitude ($Z = 0.307$, $r = 0.298$, $d = 0.625$) and were significant ($z = 21.782$, $p < 0.0001$). The researchers concluded that overlearning produced an overall moderate increase in retention. However, there has been no analysis of the effects of overlearning on endurance, stability, application and adduction measures.

Rate-building procedures have an advantage over overlearning methods. As researchers have repeatedly noted, the traditional percentage correct measures used in most overlearning studies do not allow direct measurement of the effects of repeated practice beyond the 100% accuracy criterion (Binder, 2004). It is for this reason that effects on generalized outcomes, such as skill retention, have been used to demonstrate the benefits of additional practice beyond the 100% accuracy criterion (Binder, 1993; 1996; Johnson & Layng, 1992). Nevertheless, the advantage of speeded practice beyond 100% accuracy over repeated practice beyond 100% accuracy without speed has been demonstrated only infrequently in controlled research studies. An example is a study conducted by Omrod and Spivey (1990) that directly compared the effects of overlearning and speeded practice on spelling performance. The research involved 35 undergraduate students who were trained to spell twelve difficult words in one of three conditions. In the first condition (mastery plus speeded overlearning) the participants practised the words to mastery, which was indicated by five consecutive correct spellings, and then were required to write the words quickly on 10 three-second timings. In the second condition (mastery plus non-speeded overlearning) the students practiced to mastery and were then involved in 10 additional non-timed overlearning trials. In the final condition (mastery only) the participants trained to the initial mastery criterion only. The researchers found a significant difference between conditions ($F = 3.90$, $p < 0.05$) with the mastery plus speeded overlearning condition leading to the highest scores on immediate post-tests and on those conducted after a three-week delay. However, they did not control for practice opportunities.

Another theoretical construct that is often referred to in descriptions of fluency and drill-based educational programs is automaticity. Automaticity is based on cognitive conceptualizations that describe the attainment of fast, unconscious movement in the sense that the learner's conscious attention is not required during the skill performance (Bloom, 1986; Bucklin, Dickinson & Brethower, 2000). The term was linked to reading performance in LaBerge and Samuels' model of automatic information processing in reading (Samuels, 1994). These researchers posited that when conscious attention was required for decoding words it was not readily available for comprehension (Samuels, 1994; Samuels, Schermer, Reinking, 1992). They theorized that when highly proficient readers decoded text automatically, "conscious attention" to letter-sound correspondences or to individual words was not required. As a result of automatic decoding, the reader is assumed to have sufficient "attentional capacity" to direct to the process of comprehension (Samuels, 1994; 1997).

Overlearning and automaticity are often described as interrelated concepts. That is, overlearning is proposed to increase automatic performance of a skill. For example, Bloom (1986) studied the development of talent in six fields over five years. The research included individuals who were concert pianists, sculptors, tennis stars, Olympic swimmers, research mathematicians, and research neurologists. Bloom (1986) stated that these individuals were among the most accomplished individuals in their particular fields, out of more than 500, 000 others who also began to study in that field. A consistent finding of the research was that experts allocated time to the overlearning of component skills even after they had mastered the skill. For example, the research revealed that professional tennis players continued to practice specific component movements of the game daily, such as performing serves and backhands, even after they had reached the peak of their game. The pianists might practise a specific set of musical pieces for six months or more in preparation for a public event. Moreover, Bloom (1986) reported that none of the individuals that were studied attained these high levels of performance in less than 12 years, and most took an average of 16 years. Bloom (1986) concluded that overlearning of the component skills was necessary to develop automaticity in subskills that were required for top-level performance in a particular field of application.

A critical discussion of the concept of innate talent to account for "genius" was presented by Howe (2001). He rejected the notion that gifted individuals are born with innate talents. Howe asserted that "the sheer amount of training and practice a person has undertaken turns out to be the best available predictor of high levels of expertise" (p. 195). He supported this claim with the research findings of a long-term developmental study by Sloboda, Davidson, Howe and Moore (1996) of young, gifted musicians. They found that later superior performers who joined orchestras or who became soloists were those students who had amassed more practice than the less performed students. They originally hypothesized that a small number of especially "gifted" performers would advance through the sequence of musical examinations with less effort than others, but actually found no evidence of this occurring. Rather, progression to the next level required as much practice by the more promising musicians as the others. Another study cited by Howe (2001) was conducted by Ericsson, Krampe, and Tesch-Romer (1993). They found that the number of hours of actual formal practice accrued by the most superior German violin students in the performance class of a conservatoire was at least 10, 000 hours by the age of twenty-one. Thus, repeated practice through overlearning of mastered skills was consistently highlighted as being necessary to develop automatic performance at the highest levels of achievement.

Reading research

Research has consistently shown that reading achievement is heavily reliant on high rates of component skills. Among the essential component skills necessary for reading success are reading letters, saying sounds and phonemic awareness (Yopp, 1992; Juel, 1988; Griffith & Olson, 1992; Ball & Blachman, 1991). It has been demonstrated repeatedly that letter and sound naming are some of the best predictors of future reading success (Adams, 1990). Moreover, a large reading research base indicates that it is the speed of component skills, such as letter naming, that is the crucial variable in identifying good and poor readers (Biemiller, 1978; Howell, Kaplan & O'Connell, 1979; Blachman, 1984; Walsh, Price & Gillingham, 1988; Carnine, Silbert & Kameenui, 1990; Samuels, 1997; Kail & Hall, 1994; Share & Stanovich, 1995; Meyer, Wood, Hart & Felton, 1998; Wolf & Bowers, 2000; Wolf, Miller & Donnelly, 2000; Deeney, Wolf & O'Rourke, 2001).

Wolf, Bally, and Morris (1986) found a 0.66 correlation between kindergarteners' letter naming speed and their performance on a word recognition task two years later. McCormick, Stoner, and Duncan (1994) found lower-case letter identification (r = 0.6) and consonant-identification (r = 0.6) in kindergarten to be significantly correlated with first-grade reading achievement. Similarly, studies have shown that word identification speed is crucial to successful reading (Biemiller, 1978; Stanovich, 1980, 1994; Felton, 2001). Stanovich, Nathan and Valla-Rossi (1986) reported a study by Stanovich in which he found that Metropolitan Achievement Test (MAT) scores in reading correlated 0.76 with Peabody Picture Vocabulary Test (PPVT) scores, 0.72 with speed of word naming in related contexts and 0.53 with speed of word naming in neutral contexts for third graders. In fifth grade, MAT scores correlated 0.76 with pseudoword naming time, but only 0.64 with PPVT scores.

Speece, Mills, Ritchey and Hillman (2003) also investigated the use of letter fluency (as defined by accuracy and speed) and nonsense word fluency measures as predictors of kindergarten students who were at risk of reading failure. They tested 39 children on a battery of pre-reading and reading measures (including the Word Attack and Word Identification subtests from the Woodcock-Johnson Psycho-Educational Battery-Revised, the Letter-Name and Letter-Sound Identification tests from the Texas Primary Reading Inventory, and letter-name fluency and nonsense word fluency measures) in kindergarten and then again a year later. Speece et al. (2003) reported that the nationally normed measures of reading and phonological awareness used in the study only identified 33% of the students at risk of reading failure. In contrast, the rate-based fluency measures identified 87.5% of these students. Kindergarten students were considered at risk of reading failure if they performed at or below the 25th percentile on the norm-referenced measures and poor readers in Grade 1 were identified as those students who scored at or below the 25th percentile on the Oral Reading Fluency measure, based on local norms, or on the Woodcock-Johnson Revised Word Attack. These correlational studies demonstrated that successful readers generally perform prerequisite, component reading skills at much higher rates than less successful readers.

Evidence for the relationship between decoding speed and comprehension was shown in a study conducted by Perfetti and Hogaboam (1975). They categorized third and fifth graders into two levels of comprehension skills according to scores on the reading subtest of the Metropolitan Achievement Test. Using rate measures they assessed the decoding speeds of printed words and pseudowords for the two groups. The researchers found that the children skilled in comprehension performed the decoding tasks with greater speed than the children who were less skilled in comprehension. Moreover, they found that the difference between the decoding speeds of the two groups was greater for pseudowords and low-frequency words.

A number of methods for building children's reading speeds have been reported in the reading literature. Some of these include reading whilst listening to an adult or fluent peer, as in paired reading (Dowhower, 1987; Herman, 1985), neurological impress reading (Rasinski, Padak, Linek & Sturtevant, 1994), the oral recitation lesson (Reutzel & Hollingsworth, 1993), and round robin reading (Reutzel & Hollingsworth, 1993). Some commercial programs have been produced more recently, such as the RAVE-O, Decoding Pilot Program, and Great Leaps program (Meyer & Felton, 1999). These programs have aimed to develop "fluent" reading through techniques like single word speed drills, code instruction and direct training of retrieval or lexical access (Meyer & Felton, 1999).

Possibly the best known and most commonly referenced technique for developing decoding rates in reading is the Repeated Reading method (Dowhower, 1987; Rasinski, 1989; Peterson, Scott & Stroka, 1990; Mounsteven, 1990; Scott, Stoutimore, Wolking & Harris, 1990; Meyer & Felton ,1999). Repeated Readings is a method that was developed by Samuels and based on the LaBerge and Samuels theory of automaticity (Samuels, 1994; 1997). The procedure involves speeded repeated practice as a reader re-reads a passage of connected text a number of times until he or she attains a satisfactory level of "fluency" (Samuels, 1994; 1997). Meyer and Felton (1999) published an article that reviewed "…the history of fluency training" with a focus on Repeated Reading (p. 283). In this article they defined reading fluency as "the ability to read connected text rapidly, smoothly, effortlessly, and automatically with little conscious attention to the mechanics of reading, such as decoding" (Meyer &

Felton, 1999, p. 284). Although there is no universal agreement in the reading literature concerning the operational definition or measurement of reading fluency (Rasinski, 1989; Healy & Bourne, 1995; White & Brewer, 1992), there is agreement that the implementation of repeated readings techniques has consistently produced increases in reading accuracy, rate and comprehension (Samuels, Schermer & Reinking, 1992; Reutzel & Hollingsworth, 1993; Meyer & Felton, 1999; Chard, Vaughn & Tyler, 2002; Valleley & Shriver, 2002; Dowhower, 1987; Herman, 1985; Rasinski, Linek, Sturtevant & Padak, 1994).

Dowhower (1987) investigated the effects of two repeated reading procedures on the oral reading performance of practised and unpractised passages with Grade 2 children. The study involved 17 children who (a) read at a rate of below 50 words per minute on a 200 word, second-grade passage, (b) had a word identification score of 85% or above on the same 200 word passage, and (c) had a stanine score of 4-6 on the reading portion of the Sequential Test of Educational Progress. Children meeting these criteria were assumed to be of average decoding ability but to have below-average reading rates. The children were randomly assigned to either an assisted repeated reading procedure (n = 8) involving a read-along method, or to an unassisted repeated reading procedure (n = 9) which involved independent practice. Dowhower (1987) used six basal stories at the Grade 2 level. These stories were re-written so that they each contained 400 words, had a reliability of 2.0 using Fry's method (Fry, 1977; in Dowhower, 1987), had a mean sentence length of 8-9 words, and had approximately equal numbers of simple sentences and complex and compound sentences. The stories were then divided into two parts, each 200 words in length. One of the stories was used as the overall assessment measure. The first half of the story was used as the initial test and the second half was used as the final test. The first half of each of the other stories was used as the practice passage and the second half was used as the unpractised passage. The children were involved in either the assisted or unassisted repeated reading procedures on each practice passage until they reached a criterion of 100 words per minute. No support for the use of this criterion was provided. After reaching the rate criterion on each practice passage, the children were then assessed on each of the unpractised passages. There was also an initial test, before the commencement of the intervention and a final test after the intervention phase was completed on the passages from the book selected for the overall assessments.

The results of Dowhower's (1987) study showed that reading rate, accuracy and comprehension increased significantly for both groups from the initial test to the final test on the overall assessment measure. However, between group differences were not significant. Dowhower (1987) combined the scores for both groups and found that the average reading rate almost doubled from the initial reading test to the final test, reading accuracy increased from 89% to 95%, and the percentage of comprehension questions answered correctly increased from 66% to 81%. Dowhower (1987) also showed that repeated reading of the first part of each story (practised passage) increased the reading rate of the second part of the story (unpractised passage), although only slight transfer gains were found in reading accuracy and comprehension. There were linear incremental mean score gains in reading rate and word accuracy for both groups across the five passages and in comprehension scores for the assisted group only. The mean number of re-readings required to reach the 100 word per minute rate criterion decreased incrementally across the five passages. Dowhower (1987) concluded that, regardless of the training procedure employed, repeated reading produced significant improvements in the children's reading accuracy, rate and comprehension.

Rasinski, Linek, Sturtevant and Padak (1994) investigated the effects of a "fluency development lesson" as a supplement to the regular reading curriculum with students from four second grade classrooms for 10-15 minutes daily over six months. The procedure involved teacher modelling of the passage, choral reading and paired repeated reading of passages of 50 to 100 words. The researchers observed that the reading rates of the participants involved in the "fluency development lessons" were significantly higher than the reading rates of the other children in the classes, who had not been involved in the intervention.

Herman (1985) also reported positive effects on reading rates after the implementation of a repeated readings procedure. Her study involved eight intermediate-grade students who scored in the lowest range in total reading achievement on the Metropolitan Achievement Tests and who read between 35-50 correct words per minute. The children practised passages of 100 to 175 words and a rate aim of 85 correct words per minute was to be attained before progressing to a new passage. The individuals completed five separate passages. Results revealed that repeated readings significantly increased the reading rate of all of the children. The findings also indicated learning transfer between passages. The children averaged an initial reading rate of 47 words per minute on the first passage. By the fifth passage their initial reading rate averaged 69 words per minute. Transfer of learning to "read faster" from one passage to another was also reported by Samuels (1997). He observed that participants' initial reading rates were higher for each new passage presented. Samuels

(1997) also noted that the number of re-readings required to attain the rate aim decreased as students continued the procedure.

There have also been a variety of methods reported to assess reading fluency. These have included rating prosodic quality (Meyer & Felton, 1999), latency measures, which refer to timing the intervals between the presentation of a stimulus and the learner commencing the task or producing a response (Bolich & Sweeney, 1996), or ranking on scales indicating stages of reading (Aulls, 1978). Some of these methods rely on subjective judgements and inferences which can have limited reliability between raters. Other practitioners and researchers have applied or recommended some type of rate measure of performance to assess reading fluency (Haughton, 1972; Alper, Nowlin, Lemoine, Perine & Bettencourt, 1974; Biemiller, 1978; Fuchs, Fuchs & Tindal, 1986; Dowhower, 1987; Peterson, Scott & Stroka, 1990; Samuels, 1997; McDowell & Keenan, 2001; Chard, Vaughn & Tyler, 2002; Valleley & Shriver, 2002). The use of response rates requires a definite and observable response that can be reliably counted and is unambiguous (Skinner, 1953). In the rate building techniques that have been described to increase reading rates, however, there have been no criteria for fluency other than a rate of performance specified by the teacher or researcher and there is little agreement between studies concerning optimum reading speeds for fluent performance standards. For example, a "fluency criterion" of 85 words per minute was specified by Herman (1985), whilst Mounsteven (1990) set 250 words per minute as a "fluency aim".

Summary

This literature review has described some of the very positive results that have been produced by rate-based, educational training and measurement procedures. However, it has also highlighted the requirement for further systematic, empirical research of the specific variables inherent in procedures that are aimed to improve rates of responding and produce concurrent improvements in learning outcomes.

The term “fluency” has been used as a hypothetical and essentially fluid concept in many studies involving rate-based procedures (Leach, Coyle & Cole, 2003). The operationalization of fluency, in terms of the specification of performance rates that predict or optimize the learning outcomes depicted in the set of RESAA criteria, has provided a promising research agenda (Binder, 1996). However, this definition has been misunderstood in many studies that claim to investigate behavioural fluency. As outlined here, the term “fluency” has often been misused to refer to a separate, temporal dimension of behaviour that, when achieved, produces improved learning outcomes, such as retention, endurance and application. Thus, many researchers have failed to recognise that probes for each of the RESAA outcomes (or at least for retention, endurance, stability and application) must be conducted in order to ascertain that a particular performance rate will predict the learning outcomes that are characteristic of fluent performance. This has led to research designs that rarely include measures of <u>all</u> of the outcomes depicted in the RESAA criteria. Thus, unsubstantiated claims concerning fluent performance rates have often been made in such studies and this has led to large inconsistencies in the literature concerning recommended “fluency criteria” that are claimed to ensure proficient performance. These inconsistencies and the possible inaccuracies of subsequent recommendations may misguide teachers, practitioners and researchers in judgments concerning fluent performance in educational programs or in research based on rate-building procedures.

Research designs that have not included measures for all, or even most, of the RESAA outcomes have not allowed comparisons of the effects of specific response rates on particular outcomes to be investigated. As Binder (1996) noted, optimal response rates that ensure retention may be different from those that predict endurance, for example. He described how precision teachers have found that the achievement of different response rates predict different degrees of retention and application (Binder, 2004). Thus, whether each RESAA outcome is achieved at the same or at different rates needs to be empirically investigated. Likewise, it has been impossible from studies that lack comprehensive RESAA measures to assess the effects of particular training rates on each RESAA outcome for different learners. That is, it may be expected that different performance rates predict the RESAA outcomes for different students. In other words, a performance rate that predicts the learning outcomes for one learner may not ensure the occurrence of these outcomes for another learner. Even when studies have included assessments of some of the RESAA outcomes, misconceptions concerning the definitions and appropriate measures of these outcomes have limited the validity of the results. Thus, the lack of measurement of all of the RESAA outcomes in most empirical studies and the common misinterpretations concerning the concept and measurement of fluency have limited the discovery of findings that could more clearly define the parameters of fluent performance.

Controls for practice and reinforcement effects were rarely included in the studies reviewed. It was often impossible, therefore, to attribute any improved results on measures of learning outcomes to the effects of increased response rates alone when rate-building procedures were compared to controlled-rate discrete trials methods. It could be argued that any superior results in the rate conditions could have been the consequence of increased practice or reinforcement. Conflicting conclusions were drawn from the two studies that did aim to compare the effects of rate-building procedures to controlled-rate procedures on RESAA measures whilst controlling for practice and reinforcement effects, indicating additional research is warranted. The small numbers of participants in each study and the limitations that were described in the review further emphasized the requirement for more empirical investigation.

The importance of probing the rates of freely-emitted responses following controlled-rate procedures was noted by Binder (2004) and discussed in the review. The studies that compared rate-building procedures to controlled-rate trials procedures did not include such probes. Thus, it was not possible to compare the efficiency of the two forms of training procedures in increasing response rates, nor was it possible to assess the effects of specific performance rates on learning outcomes, regardless of the method by which these rates were achieved. Furthermore, the use of only percentage correct scores in the controlled-rate conditions or on measures of learning outcomes in some of the studies did not allow comparisons of the effects of rate-building and controlled-rate procedures on RESAA outcomes beyond levels of 100% accuracy. Therefore, studies are required that compare rate-building and controlled-rate training, but that also include measures of freely-emitted responses after controlled-rate procedures and before measures of learning outcomes.

The methods of training accurate responding in rate-building procedures varied across studies. Some researchers trained, or advocated the training of accurate responding in a stage before rate-building exercises were introduced. Others maintained that accuracy and rate could be trained simultaneously. No studies have compared the relative efficiency of training accuracy to 100% before building rate to training accuracy and rate simultaneously in an interactive procedure. Therefore, there are no clear guidelines for the implementation of procedures aimed to increase performance rates for teachers, practitioners or researchers. Thus, a further area in need of investigation is highlighted.

Learning channel analysis has been used to more clearly define learning tasks in unambiguous terms and pinpoint practice with implications for teaching in multiple channels. One researcher used learning channel analysis in an innovative manner and applied it to the measurement of adduction. In Shrivastava's (2000) study learning channels were used to assess the degrees of adduction when one and two learning channels were crossed. However, a limitation concerning a possible restriction on rate on the tests that assessed adduction across two learning channels was discussed and further research is required to support Shrivastava's (2000) prediction that adduction would be greater across one learning channel than two.

The differentiation between application and adduction in some studies is not clear, nor is the differentiation entirely clear from descriptions provided by Johnson and Layng (1996). Binder (2004) clarified these concepts and emphasized that application relates to the combination of component skills that have been built to normal rate ranges in trained composite tasks, whereas adduction refers to the spontaneous combination of such components with no explicit training on the composite tasks. The utility of learning channel analysis in more clearly differentiating application and adduction measures, by describing tasks comprising these measures in terms of trained and untrained channels, has not yet been investigated.

In summary, the need for further controlled empirical research into specific variables associated with rate-building procedures and the effects of the attainment of increased response rates on the RESAA outcomes is essential. Binder (1996) noted that showing, in a systematic manner, that higher performance rates improve outcomes in one or more of the retention, endurance and application categories would be, itself, a notable accomplishment. Such research may help to clarify an operational definition of fluency, measured by learning outcomes, and to more clearly define the parameters of fluent performance. The research may influence the development of comprehensive guidelines for teachers, practitioners and researchers for the implementation of rate-building procedures and the measurement of skill proficiency.

CHAPTER 3

RATIONALE

The current research was aimed to test, under controlled experimental conditions, the model proposed by Johnson and Layng (1992; 1994) that defines fluent performance as response rates that optimize the learning outcomes depicted in the RESAA criteria. It was proposed that the research would provide an empirical clarification of some of the methods, variables and outcomes that are inherent in this operational definition of behavioural fluency through an investigation that was focused on the improvement of an academic skill in reading. Furthermore, the research was designed to investigate some of the questions that remained unanswered in fluency literature, and to overcome the limitations that have, in most empirical studies of rate-based procedures, restricted the interpretation of results and the discovery of findings that could more clearly define the parameters of fluent performance.

The first section describes the aims of the research and the innovative features of the research design that were devised to investigate specific areas in which research is required and to overcome the common limitations in other studies of rate-based procedures. In the following section, the rationale underpinning the use of the instructional procedures implemented in each of the studies is delineated. Finally, the rationale directing the overall experimental design of the research is outlined. The chapter concludes with a brief summary and lists of the research questions for Studies 1 and 2.

Major aims and innovations in the research design

The research aimed to demonstrate that the attainment of higher rates of accurate see/say phoneme responses would improve performance on measures of the learning outcomes depicted in the RESAA criteria. Although some studies have indicated performance improvements for some of these outcomes after the implementation of rate-building procedures, studies have rarely included measures for all of the RESAA outcomes. Thus, the RESAA model has not been adequately researched under controlled, experimental conditions. The current research provided an investigation of the effects of the achievement of increased see/say phoneme rates on performances on all of the RESAA measures, and a number of innovations in the design of the research allowed more comprehensive investigations of these effects. Many studies involving rate-based procedures include only pre-intervention and post-intervention measures of the effects of particular response rates on the learning outcomes. A major advancement in the design of Study 2 was the repeated assessment of RESAA rates at specific, systematic and incremental rate aims throughout the intervention period, as well as on pre-intervention, post-intervention and follow-up measures. This allowed the effects of the achievement of a number of different rate aims on the RESAA outcomes to be examined in detail. It also allowed the effects of the attainment of similar rates to be compared across RESAA outcomes and across individual participants. That is, it was possible to investigate whether similar rates would predict the same levels of performance on all of the RESAA measures, such as the same degrees of retention compared to application. Second, it aimed to investigate whether similar rates would predict the same levels of performance on the RESAA measures for different individuals. That is, it aimed to demonstrate whether similar training rates would predict similar levels of performance on retention, for example, for all individuals, or whether different training rates would predict the same levels of performance on the same outcomes for different children.

Another innovation in the design of the studies was the inclusion of probes for freely-emitted responses following the constrained-rate procedures as well as after the rate-building procedures. These probes were conducted before measures of learning outcomes were taken. This allowed assessment of the direct effects of both the constrained-rate and the rate-building procedures on see/say phoneme rates, and the concurrent effects of these rates on the RESAA measures, regardless of the method by which the rates were trained. The requirement for research that incorporated such probes was specifically emphasized by Binder (2004) and the current research provided experimental data upon which to base an answer his question: “Does it [rate] tell us more than percentage correct?” (p. 282). In Study 2, probes of freely-emitted responding after both procedures at each incremental rate aim throughout the intervention period were included. The advantage of this design was that levels of skill competency could be repeatedly and continuously compared in the two conditions over the intervention phase, and that the differential effects on response rates of additional speeded and non-speeded practice could be compared beyond a criterion of 100% accuracy. Thus, the research design allowed both the continuous assessment of the effects of the rate-building and constrained-rate procedures on response rates, and the continuous assessment of the effects of the increasing response rates on the RESAA measures. It was therefore possible to empirically determine an answer to another of Binder’s (2004) questions: “Is the rate of response a better predictor of learning outcomes (e.g., retention, maintenance and application) than the more traditional percentage correct, a dimensionless quantity?” (p. 281). This design and the graphical display of the data for each RESAA measure obtained from this research also responds to the requirement to “observe and describe the acquisition of fluency” emphasized by Allington (1984; cited in Dowhower, 1987, p. 855).

During the initial planning of the methodology for Study 2, decisions were required concerning the implementation of the most efficacious techniques for building response rates in the rate-building condition. Specifically, decisions were required relating to the most efficient methods of improving accurate responding in the rate-building procedures to be employed. A review of the rate-based literature revealed no consistency in recommendations, or in the implementation of techniques to improve accurate responding in methods aimed to increase accurate response rates. Thus, a preliminary study (Study 1) was designed to compare the relative efficiency of training see/say phonemes to 100% accuracy in a stage before rate-building exercises were introduced to training the accuracy and rate of see/say phonemes simultaneously in a more interactive procedure. The students each learnt two lists of phonemes under two teaching conditions. Efficiency was measured in terms of economy of teaching time and learning opportunities. Economy of time was measured by comparing which condition produced the greatest effects on each of the dependent variables over an equal period of time. The economy of effort was assessed by measuring the number of practice repetitions and reinforcement frequencies that were required to produce the accurate see/say phoneme training rates attained by each of the participants learning lists of phonemes under the two conditions. The results of this study were then used to inform decisions concerning the most efficacious procedures for building rate that were to be employed in the rate-building condition of Study 2.

Two other dimensions of investigation were designed to examine the effects of learner characteristics on the efficacy of the training procedures and on the attainment of response rates and concurrent improvements in RESAA rates. In Study 1, the effects of the age of the children on the degrees of efficiency of the two methods in training accurate see/say rates and in producing improved RESAA rates were examined. In Study 2, the effects of three levels of reading ability on the attainment of accurate see/say rates and RESAA rates were investigated. The standardized measure used to test the level of reading ability of the children was the third edition of the Test of Early Reading Ability (TERA-3; Reid, Hresko & Hammill, 2001).

The TERA-3 is a direct measure of the reading ability of children aged between three years six months and eight years six months. It assesses children's mastery of early-developing reading skills and comprises three subtests. The Alphabet subtest measures children's knowledge of the alphabet and its uses. The Conventions subtest measures knowledge of the conventions of print and the Meaning subtest measures children's construction of meaning from print. For each subtest, standard scores are provided and an overall reading quotient is calculated using the three subtest scores. Reliability coefficients for subgroups of the normative sample (e.g., race and gender) and for the entire normative sample were approximately 0.90 for 30 of the 32 coefficients reported. According to the reading quotients, children were categorized according to ability groups. The children in the current studies were classified as either average readers (quotients of between 90 and 110), poor readers (quotients of between 70 and 79), or very poor readers (quotients of between 35 and 69). The classification of children in terms of their assessed levels of reading ability allowed the examination of another variable that might affect the achievement of accurate response rates and RESAA rates of the children in the studies.

A further goal of the current research was to overcome the limitations that were highlighted in the studies reviewed in Chapter 2. A common problem in many studies was the lack of controls for practice and reinforcement effects. Thus, any findings that showed improved results following rate-building procedures, or that showed superior results in rate-building conditions compared to results in controlled-rate conditions, could be attributable to increased practice or reinforcement, rather than to the effects of increased response speeds. In Study 1, the numbers of practice repetitions and the quantities of contingent reinforcer presentations were calculated after the intervention was completed. Study 2 was specifically designed to ensure that the quantities of practice repetitions were equal in the rate-building and constrained-rate repeated practice conditions for each child. Following the completion of the intervention, the numbers of reinforcers presented to each child in both conditions were calculated. Therefore, the degree to which results could be attributed to the effects of increased response speeds, rather than to the effects of increased practice and reinforcement were investigated in this research.

Some other limitations of the studies described in Chapter 2 were the result of inappropriate measures of the learning outcomes. In some studies, retention periods were short and may not have represented significant periods of no practice. In the current research design, both studies included repeated measures of short-term retention, which were assessed after three days of no practice in Study 1 and after one week of no practice in Study 2. However, each study also included measures of long-term retention, which were conducted after three months of no practice. This design allowed the continuous measurement of the effects of the attainment of specific rate aims on short-term retention over the intervention period, and the examination of the effects of the final response rates achieved by each individual on long-term retention. Additionally, the effects of the response rates achieved by the final timings in the intervention phases on the long-term retention of rates on the endurance, stability, application and adduction measures were also conducted during the three-month follow-up phases.

Descriptions of studies in the literature review showed that the some of the measures used to probe endurance were inappropriate and limited the validity of the results. For example, the intervals used to probe endurance were sometimes of equal length to those used during rate-training and did not, therefore, measure endurance according to the definition provided by Johnson and Layng (1996). The endurance probes in the current studies were three-minute response intervals, which comprised durations that were three times the length of the rate-training intervals. The use of three-minute intervals increased the likelihood of obtaining more valid measures of skill endurance.

Claims concerning skill stability were made by Bonser (2002), but these were largely unsubstantiated in his research, due to the lack of appropriate stability measures involving distracting stimuli. The children's response rates were assessed in the presence of three forms of distracting stimuli in the current studies to assess skill stability. The stimuli represented a visual distraction, an auditory distraction and combined visual and auditory distractions. Three forms of distraction were used to assess the effects of the different types on skill stability. A child's animated movie was used in each of the stability probes. The movie represented a significant distraction as the children were very interested in the animation and its soundtrack.

Application was more comprehensively assessed in the current research by using two forms of probes comprising two separate tasks. The first task required the participants to see/say the individual phonemes in pseudowords, whilst the second task required the children to blend the phonemes to see/say whole pseudowords. These application probes were designed to assess two levels of task complexity in applying the component see/say phonemes skill.

Application and adduction measures were not clearly differentiated in the Bonser (2002) study and other researchers have misinterpreted the definitions of these concepts. Binder (2004) clarified the definitions of application and adduction, by describing application as occurring within the context of trained composite tasks and adduction as occurring within the context of untrained composite tasks, thereby highlighting the possible utility of learning channel analysis in planning and describing appropriate tasks to measure skill application and adduction. Thus, the current research was designed to investigate the use of learning channel analysis to define application and adduction measures, by describing tasks comprising these measures in terms of trained and untrained channels. Shrivastava (2000) applied learning channel analysis to assess degrees of adduction when one channel and two channels are crossed. However, the possible confounding of results, by insufficient rates of component skills required to complete the task involved in the measure of adduction across two learning channels, limited the interpretation of these findings. Therefore, the current research was designed to examine the levels of adduction that occur for a one-channel cross and a two-channel cross after the attainment of specific incremental accurate see/say rates. Thus, the relationships between learning in specific channels and the utility of using learning channel analysis to plan instructional programs and in designing clear and appropriate assessments to measure learning outcomes were investigated. The examination of learning channels, in the ways described, also responded to encouragements from Lindsley (1994) for researchers to undertake more research in this promising area of study.

Rationale for the instructional procedures

The procedures and the materials used in the rate-building conditions of both studies were designed to avoid, as far as possible, any externally imposed restrictions on response rates, and to allow freer-rate responding. The literature review outlined the four free-operant freedoms described by Lindsley (1996), which were used as guidelines to ensure freer-rate responding in the current research. Binder, Lindsley, and Johnson and Layng have provided recommendations for designing procedures and materials that ensure minimal restrictions are imposed on learners' response rates (Binder, 1996; Lindsley, 1996; Johnson & Layng, 1994; 1996). These were taken into consideration when planning the instructional procedures and materials used in the current interventions.

The freedom to self-present stimuli was ensured by printing multiple examples of the letters and digraphs on cards that were placed randomly each timing in a circular array on the participants' desks. A circular arrangement was used to encourage continuous responding. No attempts were made to externally pace the responses of the students. Likewise, the children were allowed to develop any response rhythms they chose. For example, some children would stand and transfer their weight from foot to foot during responding, whilst others would point to each card with a pencil and tap their rhythms in doing so. In keeping with the suggestions of Lindsley (1996), the participants were allowed to say, "skip" for any phonemes they were unable to immediately recall, maintaining response speeds.

The participants were instructed to continue reading around the circle continuously until the timer emitted a sound. Thus, the freedom to repeat responses was ensured and it was possible to record continuous responses over the entire timing intervals. This allowed repeated measures of behaviour to occur and the documentation of moment-to-moment changes in behaviour.

The freedom to speed was guaranteed in a number of ways. In order to avoid ceilings being placed on rate, the phoneme cards and the pseudoword cards were placed in the circular array described previously. This eliminated time that would be required for flipping or sliding cards. Johnson and Layng (1994) encourage a minimum of page turning and cross-page referencing. Thus, for the hear/mark adduction task, a large number of stimuli were included on each page and only one page was given to the student at a time. The researcher had another page ready to slide quickly in front of a student when he or she had completed his or her sheet. During the hear/say spelling adduction task and hear/mark spelling adduction tasks, a new word was read to the students immediately after they had completed their responses to a previous word. These techniques ensured the most minimal ceilings were imposed on the students' response rates. Several versions of the worksheets were also provided to avoid memorization as suggested by Johnson and Layng (1994). Ceilings were also avoided by implementing feedback and error correction procedures after each timing, and not during the sprints or drills. A further measure taken to avoid response rate restrictions was the use of an electronic timer that could be set to count down specific intervals of time and that emitted a sound when the interval was completed. Johnson and Layng (1994) suggested visual timers, such as sand timers, should be avoided as students' rates can be slowed by the distraction of looking at the timer.

Possible restrictions on response rates that may have been produced by low rates of component skills were taken into consideration when planning the design of the adduction tests. The Adduction 2 tests involved the participants circling the correct phonemes in the appropriate order, rather than writing the words to avoid the possibility that slow writing speeds would place restrictions on the response rates on these adduction probes. Similarly, the Adduction 1 tests were originally designed to require the participants to orally spell the words using letter sounds and not letter names. This reduced the likelihood that low rates of saying letter names, a separate skill from saying letter sounds, would restrict the response rates on the Adduction 1 probes. However, the possibility that these Adduction 1 tests did not provide entirely valid measures of the adduction of the see/say phonemes skill in Study 1 is discussed in Chapter 6. Thus, modifications to the Adduction 1 measurement task were made, before the commencement of Study 2, and the revised test involved the participants orally spelling the words with letter names. The children's knowledge of the names of the letters comprising the words were assessed before the commencement of the intervention to ensure the rates on the Adduction 1 probes were not restricted by inaccurate letter naming.

Rate aims were specified in terms of ranges of performance speeds. This practice was recommended by Haughton (in Binder, 1996). He suggested that the specification of rate aims in ranges accounts for variation among individuals. He suggested that some individuals will strive to achieve the highest possible level of performance, whilst others will be content with reaching the lower levels of performance. It was important in the current research to specify rate aims in ranges to ensure that measurement on the RESAA outcomes could be conducted at clearly defined levels of performance. If only single rates of performance were specified as the rate aims, there would be a risk that students may exceed this rate on a particular timing, and the RESAA assessments would not occur at the same levels of performance for all participants. Thus, ranges of 20 ppm were specified for each rate aim.

The rate building procedures employed in the rate-building conditions in Studies 1 and 2, and during the rate-building stage in the rate-building after accuracy (RBAAT) condition of Study 1, comprised a sequence of sprints and drills. Research has shown that performance rates do not endure over extended intervals of time until learners have attained sufficient response speeds, and this has led some researchers to suggest training over very short periods of time known as “sprints” (Binder, 1996; Johnson & Layng, 1994). The sprints employed in the current interventions were 10-second intervals of timed repeated practice. Drills are longer intervals of timed repeated practice (Johnson & Layng, 1994). Shrivastava (2000) scheduled three 10-second sprints between each drill, a procedure which was implemented in the current study. However, Shrivastava (2000) only used drills and probes comprising 30-second intervals. The limitation of these measures, of only providing approximate per minute rates, was overcome in the current research design by systematically increasing the length of the drills in 15-second increments, from 15 seconds to 60 seconds. This allowed the participants’ response rates to be trained over one minute, and for all probes to comprise 60-second intervals. Thus, accurate measurements of actual performance rates were obtained on all probes, rather than approximations of performance obtained by calculating per minute rates from performances on shorter response intervals.

The constrained-rate repeated practice condition in Study 2 and the accuracy training stage of the RBAAT condition in Study 1 comprised controlled-rate discrete trials training, and one stimulus was presented every three seconds under experimenter control. Thus, it was impossible for the children to build response rates above 20 ppm during the controlled-rate trials. This allowed the comparison of the effects of speeded repeated practice to the same quantity of non-speeded repeated practice on the RESAA probes in Study 2. In Study 1, the design allowed the comparison of the effects on the

RESAA measures of learning the phonemes to 100% accuracy without speed before beginning rate-building exercises, to building accuracy and speed simultaneously.

Rationale for the experimental design

The research comprised a single-subject repeated measures design. In repeated measures designs the same participant is involved in two or more conditions (Boniface, 1995). In the current studies each participant trained under both of the experimental conditions. Repeated measures designs have a number of advantages over group based designs, including the requirement for fewer participants (Malim & Birch, 1997). Moreover, there are fewer threats to internal validity, caused by individual differences between participants, as each serves as his or her own control (Malim & Birch, 1997). The present research project included a total of 24 children and 12 participated in each study. Thus, the design of the current research allowed for repeated measures of the effects of interventions for a number of participants, and threats to internal validity were minimized.

One problem with single-subject designs concerns carry-over effects. These occur when the effects of one treatment may still be present when the next treatment is administered (Cozby, 1993). There was a possibility of carry-over effects between the rate-building and constrained-rate practice conditions in Study 2. That is, experience in responding quickly and building rate in the rate-building condition may have influenced increases in rate in the constrained-rate practice condition. However, any carry-over effects would only produce more positive results for the constrained-rate practice condition and this could only provide credibility for any superior results in the RB condition.

Order effects were also considered in the current research project. Order effects can occur when participant performance improves as a consequence of repeated practice with the same task sequence, as in practice effects (Cozby, 1993). Order effects can also occur when performance deteriorates as a consequence of tiredness, boredom or distraction, as in fatigue effects (Cozby, 1993). To minimize the occurrence of order effects, counterbalancing techniques were employed (Goodwin, 1995). The participants were randomly assigned a set of phonemes for a particular condition and were also randomly assigned to begin baseline testing, training, post-testing and follow-up testing in either condition. Where practicable the presentation of RESAA tests was also randomized.

The results chapters include both within-subjects and between-subjects data analysis. In group-based studies, the results can frequently indicate that an intervention is effective even though there is high variability within the group (Neuman & McCormick, 1995). However, the current research design allowed for the analysis of both individual participant data and the analysis of group trends. Thus, intrasubject variability was highlighted and could be considered in the analysis of group trends.

A procedure was implemented to substantiate internal validity. Internal validity relates to the degree to which the results are attributable to the intervention (Barlow & Hersen, 1984). Inter-observer reliability was calculated to substantiate internal validity (McReynolds & Kearns, 1983). This procedure involved the videotaping of a number of randomly selected sessions and a second, trained observer scoring the behaviour to be compared to the scoring of the same behaviour by the researcher. All of these procedures are detailed in the method chapters for Study 1 and Study 2.

Summary

Although rate-building techniques have long been recommended as powerful methods for preventing and remediating learning problems, there remains a lack of empirically validated data concerning the specific effects of certain variables comprising these techniques. In addition, there are inconsistencies in the conceptualization of fluency and appropriate measures of fluent performance, which has resulted in a lack of guidelines for the implementation and measurement of rate-building procedures in educational programs and research studies.

The objectives and the rationale underpinning the design of the current research project have been outlined. The aim of overcoming some of the limitations that are commonly highlighted in other studies involving rate-based procedures and measurements has been a constant focus in the current research. A number of innovations in the research design, in the implementation of procedures, and in the measurement techniques used in the research were aimed to specifically investigate areas in which questions still remain in the literature. The controlled, systematic and empirical investigation of the RESAA model proposed by Johnson and Layng (1992; 1994) and the examination of specific variables inherent in rate-based procedures and measurements were aimed to more clearly define fluent performance and to provide guidelines for the implementation of these methods by researchers and practitioners.

The research questions for Study 1 and then for Study 2 are listed below:

Research questions for Study 1

1. Will training students to see/say phonemes with 100% accuracy on two consecutive trials (RBAAT) produce higher see/say phoneme training rates than rate-building without prior accuracy training (RB) over an equal time period?
2. Will training students to the 100% accuracy criterion before building rate (RBAAT) produce lower error rates than rate building without prior accuracy training (RB) over an equal time period?
3. Will training students to the 100% accuracy criterion before beginning rate-building exercises (RBAAT) result in higher correct response rates on each of

the RESAA outcomes compared to rate-building without prior accuracy training (RB)?

4. Will training the participants to the 100% accuracy criterion before beginning rate-building exercises (RBAAT) result in higher correct response rates on each of the RESAA measures three months after the intervention is completed compared to rate-building without prior accuracy training (RB)?
5. Will more phoneme repetitions be required to acquire and maintain accuracy in the RB condition or in the RBAAT condition?
6. Will a greater quantity of reinforcement be required to produce accuracy and speed in the RB or RBAAT condition?
7. Will the effects of the RB and RBAAT training conditions differ for the pre-primary participants (aged between 4 years 3 months and 5 years) and the Year 2 participants (aged between 6 years 6 months and 7 years 2 months)?

Research questions for study 2

1. Will speeded repeated practice of one set of phonemes produce higher see/say training rates than the same quantity of constrained-rate repeated practice of another set of phonemes for each child?
2. Will building the speed of see/say phonemes produce higher rates on the RESAA measures than the same quantity of repeated practice of see/say phonemes at a constrained rate for each the participant?
3. Will a particular see/say phoneme training rate range predict all of the RESAA outcomes, or will each outcome be predicted by different see/say phoneme training rates?
4. Will particular see/say phoneme training rates predict a particular RESAA outcome for all of the children, or will different see/say phoneme training rates

predict a particular outcome for different children?

5. Will higher see/say phoneme training rates be necessary to predict adduction for a two learning-channel cross (i.e., for a hear/mark task) than for a one learning-channel cross (i.e., for a hear/say task) for each child?
6. Will speeded repeated practice on one set of phonemes produce higher retention of RESAA rates than the same quantity of constrained-rate repeated practice of another set of phonemes three months after the termination of the intervention for each child?
7. Will the children scoring within the very poor, poor and average ranges on the TERA-3 be able to build similar see/say phoneme training rates?
8. Will the participants who were classified as poor and very poor readers on the TERA have to build higher see/say training rates than the average readers to predict similar rates on the RESAA measures between groups?

CHAPTER 4

STUDY 1

A comparison of the efficiency of training see/say phonemes to 100% accuracy before rate-building to training accuracy and rate simultaneously for Year 2 and pre-primary children

CHAPTER 4

METHOD

Design

Study 1 involved within-subjects designs in which the participants trained under both experimental conditions and served as their own controls. The experimental condition for which each child commenced assessments or intervention was randomly assigned to control for order effects. Unknown phonemes were also randomly allocated to two sets for use in two experimental conditions for each child.

There were four phases in Study 1. Phase A was a one-week period in which the baseline measures were conducted. During the baseline phase each participant was involved in one-minute see/say phonemes pre-tests on both sets of phonemes. They were also assessed on the endurance, visual stability (VS), auditory stability (AS), combined auditory and visual stability (CAVS), Application 1, Application 2, Adduction 1, and Adduction 2 pre-tests for both sets of phonemes.

Phase B followed the baseline phase and comprised an eight-week period of intervention. The study was conducted over four consecutive days per week. Two of these days were allocated for training in the rate-building (RB) condition and the other two days were allocated for training in the rate-building after accuracy training (RBAAT) condition. During Phase B, the children learned a different set of phonemes in each of the experimental conditions. The RB condition comprised a training procedure that trained the accuracy and rate of see/say phonemes simultaneously. In the RBAAT condition the accuracy of see/say phonemes was trained to 100% in a stage before rate-building commenced.

Phase C immediately followed Phase B for a duration of one week. During Phase C the RESAA post-tests were administered. These were conducted under the same conditions as the pre-tests in the baseline phase. The retention tests in Phase C were short-term retention tests and measured see/say phoneme rates after a three-day period of no practice.

The final phase in the study, Phase D, was a one-week period during which the RESAA follow-up tests were conducted. Phase D commenced three months after the termination of the intervention in both conditions. The tests assessed the long-term retention of see/say phoneme training rates and the long-term retention of rates on the endurance, stability, application and adduction measures.

The design therefore followed an A-B-C-D format. Figure 4.1 outlines the sequence of phases.

Participants

Teachers were asked to nominate students in their classrooms whom they believed were having difficulty in reading. A pool of 10 children from pre-primary classrooms and 36 children from Year 2 classrooms who had been identified as having reading problems by their teachers were tested on the revised Wechsler Pre-Primary Scale of Intelligence (WPPSI-R; Wechsler, 1989) or on the third edition of the Wechsler Intelligence Scale for Children (WISC-III; Wechsler, 1992), depending on their ages. Each child was also given the third edition of the Test of Early Reading Ability (TERA-3; Reid, Hresko & Hammill, 2001). Pre-primary aged children were also tested on their knowledge of the letter sounds

FIGURE 4.1: EXPERIMENTAL DESIGN FOR STUDY 1

of the alphabet. The children from the Year 2 classrooms were tested on their knowledge of a list of 29 phonemes, which comprised 27 listed by Carnine, Silbert and Kameenui (1997) and an additional two digraphs. An example of one of the digraphs was “ph” as in “phone”. The two additional digraphs were “ue” as in “value” and “re” as in “return”. These were added to increase the pool of phonemes from which the lists used in the study were created, as some of the higher ability readers were able to read some of the more common digraphs such as “sh” and “th”. The digraph list appears in Appendix 2.

Twelve children were chosen for participation in Study 1 based on the scores on each of the pre-intervention tests. Five children were selected from a Year 2 mainstream primary classroom whilst the remaining seven students were chosen from two pre-primary classrooms. All of the students scored within the low average to average ranges (IQ range between 80 and 109) for Verbal IQ on the WPPSI-R or WISC-III. All of the Year 2 children scored within the poor (quotients of between 70 and 79) and very poor (quotients of between 35 and 69) reading ranges on the TERA-3. Five of the pre-primary children also scored within these ranges on the TERA-3. The two remaining pre-primary children scored within the below average range on the TERA-3 (quotients of between 80 and 89). The ages of the pre-primary children involved in Study 1 and their scores on the WPPSI-R and on the TERA-3 are shown in Table 4.1. The ages and scores on the WISC-III and TERA-3 for the Year 2 children are shown in Table 4.2. The names in the tables are not the real names of the children involved in the study.

Table 4.1: The ages and scores on the WPPSI-R and TERA-3 for the pre-primary participants.

Name	Age (years : months)	WPPSI-R (Verbal IQ)	TERA (Reading Quotient)
Reece	5:0	82	66
Jake	4:10	81	70
Bryce	4:4	86	76
Leon	4:9	81	74
Elena	4:3	86	79
Martin	4:8	90	89
Renee	4:3	100	85
Means	4:7 (SD = 0.28 years)	86.6 (SD = 6.28)	77 (SD = 7.48)

Table 4.2: The ages and scores on the WPPSI-R and TERA-3 for the Year 2 participants.

Name	Age (years : months)	WPPSI-R (Verbal IQ)	TERA (Reading Quotient)
Karl	6:9	84	79
Adam	7:2	95	72
Jimmy	6:6	94	79
Christine	6:8	89	74
Tanya	6:9	93	79
Means	6:8 (SD = 0.28 years)	91 (SD = 4.05)	76.6 (SD = 3.01)

Materials

Two separate sets of phonemes were used during training for the Year 2 and pre-primary participants. The pre-primary sets comprised seven phonemes represented by individual letters. The Year 2 sets consisted of six phonemes represented by digraphs. These sets contained only those phonemes that were identified as being read incorrectly by each of the participants on the phoneme pre-intervention tests. The lower-case letters were printed on white card (5cm x 5cm) and laminated. There were two examples of each phoneme in each set in order to avoid participants learning the order of presentation during the intervention exercises. Each participant learned one set of phonemes in the RB condition and the other set of phonemes in the RBAAT condition. The phonemes comprising these sets are shown in Appendix 3.

The letter and digraph sets were also used to form two pre-primary and two Year 2 pseudoword sets. For the pre-primary participants, pseudowords contained only letters that were in included in the phoneme training sets. For the Year 2 participants, the pseudowords comprised only those digraphs that were contained in the phoneme training sets plus an additional vowel and a consonant. The vowel and the consonant in each pseudoword were included to allow the formation of phonetically regular words using the digraphs. The vowel “a” and the consonant “m” were chosen because each participant could read these phonemes accurately on three consecutive trials and without hesitation. The pseudowords were also printed on card (11cm x 5cm) and laminated. There were two examples of each word in each set. The pseudowords were used for the application and adduction tests and are listed in Appendix 4. The target phonemes appeared at the beginning and at the end of the pseudowords the same number of times. Examples of the Year 2 pseudowords are “maph”, in which “ph” is the target digraph, and “urma” in which “ur” is the target digraph. Examples of the pseudowords for the pre-primary children are “tec” and “nev”, in which all of the letters represented target phonemes.

Worksheets were created for use during the Adduction 2 tests. These were hear/mark tasks that required the participants to circle the correct letters representing the target phonemes in the appropriate order to spell the pseudowords. For example, when a pre-primary child heard the pseudoword “roj”, he or she was required to circle the letters “r”, “o” and “j” in this order. On each of the pre-primary worksheets there were six rows containing six letters. Three of these letters corresponded to target phonemes, whilst the remaining three letters served as distractions. Target and distracter phonemes were randomly ordered in each row.

Similar worksheets were created for the Year 2 participants for use during the Adduction 2 tests. They differed from the pre-primary worksheets in that the rows contained both single letters and digraphs. There were four single letters and two digraphs in each row. Again three of the phonemes were target phonemes whilst the three remaining phonemes represented distractions. For example, when the children heard the pseudoword “amir”, they were required to circle the “a”, “m” and “ir” phonemes in this order. They were also randomly ordered in each row.

There were six variations of each worksheet for both the Year 2 and pre-primary participants. Each worksheet differed in two ways. First, the order of the target phonemes in the row changed and the distracter phonemes were altered. Second, the words were read in different orders. These measures reduced the likelihood that the participants learned the order of the words as they were presented and also overcame the problem of participants memorizing the placement of letters to be circled in each row. The worksheets and their variations are shown in Appendix 5. A lead pencil was used by each of the participants to mark the appropriate letters during the Adduction 2 tests.

A small electronic timer was used to accurately measure the duration of all timings in the study. The timer emitted a sound when the time interval was completed. For example, when the timer was set to measure 15 seconds the timer counted down and emitted the sound when the display reached zero seconds.

Each participant was given a sticker chart that displayed five grids each containing 10 squares. Participants’ targeted responses were reinforced by tokens, which were placed in the squares on the chart. The stickers were of various cartoon type pictures. In the final square of each grid were icons depicting “happy faces”. These indicated to the children that they had accumulated 10 stickers and were allowed to choose an item from the treasure box. This box contained small edible items and toys, such as lollipops, jelly sweets, McDonalds® toys, toy rings and bracelets, marbles, small action figures and novelty pencils. When the participants reached the final square on the final grid on the chart they were awarded a certificate and allowed to take the sticker chart home. They then began a new chart. An example of the sticker chart with stickers is shown in Appendix 6.

Independent variables

The independent variables were the methods of instruction used to increase the participants’ correct see/say phoneme rates in the two conditions. In the RBAAT condition the accuracy of see/say phonemes was trained to 100% accuracy on two consecutive trials in a stage before rate-building of see/say phonemes commenced. In the RB condition, the accuracy and rate of see/say phonemes were trained simultaneously.

Dependent Variables

Correct and incorrect see/say phoneme training rates comprised two of the dependent variables. Correct training rates were defined as the number of accurate see/say phonemes per minute on the one-minute timings. Correct responses comprised the children saying the appropriate letter sound and not the letter name for the pre-primary participants. For the Year 2 participants, correct responses were recorded when the children produced the digraph sound and not the individual letter sounds or names. Incorrect rates comprised the number of inaccurate phonemes per minute. Incorrect responses were recorded when participants said inaccurate phonemes, omitted phonemes during timings or indicated that they did not know the phoneme. Correct and incorrect rates were measured on one-minute timings during the see/say pre-tests, the short-term retention post-tests and the long-term retention follow-up tests. Correct and incorrect see/say phoneme rates were also assessed on each of the endurance, stability and application pre-tests, post-tests and follow-up tests. Rates were expressed as the number of phonemes per minute (ppm).

The adduction tests involved the measurement of two other dependent variables. In the Adduction 1 tests, the children's correct and incorrect hear/say phoneme rates were the dependent measures. Correct hear/say rates were expressed as the number of correct phonemes per minute (ppm). Correct hear/say responses for the pre-primary participants comprised the children saying each correct letter sound in the appropriate order after hearing a pseudoword. For example, when the participants heard the word "tec", they were required to say the phonemes /t/, /e/ and /c/ in that order. Correct hear/say responses for the Year 2 participants consisted of the children saying the correct digraph in the appropriate order of the word. For example, when they heard the word "maph", they were required to say the phonemes /m/, /a/ and /ph/ in that order. Incorrect hear/say rates were expressed as the number of incorrect responses per minute. Incorrect hear/say responses involved the participants saying incorrect phonemes, saying phonemes in the incorrect order, omitting phonemes, using letter names instead of letter sounds or indicating that they were unable to perform the task.

The Adduction 2 tests involved measurement of correct and incorrect hear/mark rates as the dependent variables. Correct hear/mark rates were also expressed as the number of correct phonemes per minute (ppm). Correct hear/mark responses were defined as each correct target phoneme circled in the appropriate order of the word they heard. For example, when the pre-primary children heard the word “ven”, circling “v”, “e” and “n” in that order would constitute three correct hear/mark responses. When the Year 2 participants heard the word “oima”, circling the phonemes “oi”, “m” and “a” in that order would comprise one correct response for the target digraph. Incorrect hear/mark rates were expressed as the number of incorrect phonemes per minute. Incorrect hear/mark responses consisted of the children circling incorrect phonemes, circling phonemes in the incorrect order, omitting phonemes or indicating that they were unable to perform the task.

The number of practice repetitions that were required by the participants to increase their see/say phoneme rates during the intervention constituted another dependent variable. A practice repetition involved an exposure to a phoneme. In the RB condition the participants received practice repetitions during the initial introduction to each phoneme, during rate-building exercises and during the error correction procedure. In the RBAAT condition, the children received practice repetitions during the accuracy-training phase, during the rate-building exercises and during the error correction procedure in the rate-building stage.

The quantities of reinforcement (i.e., the number of reinforcer presentations) in each condition comprised the final dependent variable. Each instance of contingent reinforcement was counted and tallied in the two conditions. This allowed for the comparison of the reinforcement quantities that were necessary to attain the see/say phoneme rates achieved by each child in the two conditions.

<u>Measurement and scoring of the dependent variables</u>

See/say rates for each set of phonemes were initially measured for each condition on one-minute timings during the baseline phase. In the intervention phase, see/say training rates were measured on one-minute timings during the rate-building procedure in the RB condition and during the rate-building stage in the RBAAT condition. See/say rates were also measured on one-minute timings for the stability and application pre-tests, post-tests and follow-up tests and for the retention post-tests and follow-up tests. On the endurance pre-tests, post-tests and follow-up tests the see/say rates were measured on three-minute timings.

Scoring of the see/say rates on the one-minute timings and on the retention and stability tests involved one point being noted for every correct response and one point was recorded for each incorrect response over the one-minute interval. From these scores correct and incorrect rates over one minute were obtained. During the endurance tests one point was recorded for each correct response and one point was noted for each incorrect response over the three minutes. From these scores a rate over the three minutes was obtained. These rates were then divided by three to gain per minute rates.

The Application tests were scored differently for the pre-primary and Year 2 participants. The pseudowords used with the pre-primary children contained only the target phonemes. Thus, one point was scored for each correct and for each incorrect phoneme over the one-minute intervals and per minute correct and incorrect rates were obtained from these scores. The pseudowords used with the Year 2 children contained not only the target digraphs but also the “a” and the “m” phonemes that were required to form phonetically regular words. Correct responses comprised saying the correct <u>digraph</u> in the appropriate order in the word and only one point was noted for each target digraph and not the two separate phonemes. To control for the time that was taken to say the “a” and the “m” phonemes, the points noted for each correct digraph over the one-minute application test timings were doubled as there were four letters in each word, two forming the target digraph and two that were constants but were not scored. These were then expressed as per minute rates.

The adduction tests for the Year 2 children were scored in a similar way to the application tests. One point was noted for each correct digraph articulated by the participants in the correct order on the Adduction 1 tests. On the Adduction 2 tests, one point was recorded for each correct digraph that was circled in the appropriate order on the worksheets. To control for the time spent saying the other two phonemes in each case, the scores were doubled. These scores were then expressed as per minute rates. For the pre-primary participants, one point was recorded for each correct phoneme and these scores were expressed as per minute rates.

Procedure

Written consent to participate was obtained from the principals of the two schools and then by each of the participants’ parents before the commencement of the study. Oral consent was also given by each of the children before they participated in the research project.

All tests and treatment procedures were administered in separate rooms from the classrooms, but within the schools. Each child was tested and received the treatment procedures individually. The children were seated at desks and the researcher sat adjacent to them. During timings the researcher recorded the number of correct and incorrect responses made by the participants.

Phase A: Baseline

The participants were randomly assigned to begin training in either the RB or the RBAAT condition. Baseline testing in the assigned condition then commenced for the participants. When they had completed the baseline testing in one condition, they were immediately involved in the baseline testing for the other condition. Reinforcement was made contingent on active participation during the baseline testing.

The see/say tests for each phoneme set were the first to be conducted. During the see/say phoneme baseline tests, the children were informed that they were going to read some letter sounds. The children were shown two examples of phonemes that were not included in the RB and RBAAT sets. The pre-primary children were shown the difference between saying the letter sounds and the letter names with these examples and were told to say letter sounds only. The Year 2 students were shown how to say the digraph and not the sound of each letter in the digraph with their two examples.

The appropriate set of phoneme cards was then placed in a circular arrangement on the participants' desks with the phoneme side facing upwards. The children were instructed they were to begin at a randomly chosen phoneme in the circle and to move around the circle saying as many of the sounds as possible. They were shown the timer and told that they were to continue reading until the timer emitted a sound. The participants were encouraged to attempt to read the phonemes as quickly as possible and to say, "skip" for any they were unable to read. The timer was set to measure a one-minute duration and the children were told to begin reading at the same moment that the timer was started.

Following the see/say tests for each phoneme set, the endurance, VS, AS, CAVS, Application 1, Application 2, Adduction 1 and Adduction 2 pre-tests were administered in random order. During the endurance pre-tests the phoneme cards were placed in same circular arrangement as for the initial see/say phonemes tests. The participants were given the same instructions as for the initial see/say tests but were informed that they were to be timed over a longer duration. The timer was set to measure a three-minute interval and the children were instructed to begin reading as quickly as possible as the timer was started.

The VS, AS and CAVS pre-tests followed the same format as the see/say tests. However, a different form of distraction was presented for each type of test during the one-minute timings. Before the VS pre-tests, the children were informed that they were going to say the sounds as before but that a movie would be played without the sound whilst they read the phonemes. They were told to try to ignore the movie and to read as quickly as possible. A child's animated movie entitled "The Jungle Book" was played without sound on a large television screen that had been placed directly in front of the participants' desks throughout the VS pre-tests. During the AS pre-tests, the picture was turned off and the movie sound track was played over the one minute in which the children read the phonemes. The CAVS pre-tests were conducted whilst the movie was played with the picture and the sound.

The Application 1 pre-tests involved the use of the pseudowords. Two examples of pseudowords that were not contained in either of the RB and RBAAT sets were used to demonstrate the requirements of the task to the participants. The pre-primary children were shown how to orally segment each of the words by reading the individual phonemes in the pseudowords. The Year 2 participants were shown how to orally segment the words by reading the digraphs and the other individual phonemes in the words. The cards on which the set of pseudowords were printed were then placed in a circular arrangement on the desks of each of the children with the words facing upwards. The students were instructed to begin at a randomly chosen word, to read each phoneme or digraph in the word before moving to the next pseudoword, and to continue until the timer sounded. They were again encouraged to attempt to read all of the phonemes or digraphs as quickly as possible but were allowed to say, “skip” for any they were unable to read. The timer was set to measure a one-minute interval and the children were instructed to begin as the timer was started.

The Application 2 pre-tests also involved the use of the pseudowords and were one minute in duration. The participants were shown how to blend the phonemes or digraphs in the pseudowords to read the entire word with the two examples that were not included in the RB and RBAAT sets. They were then given the instructions to begin reading at a randomly chosen word, to continue reading as quickly as possible until the timer sounded and to say, “skip” for any words they were unable to read.

The Adduction 1 pre-tests were conducted over one-minute timings. The task required the participants to orally segment the pseudowords as they had in the Application 1 pre-tests. However, the task was a “hear/say” activity as they were no longer able to see the words but rather had each word read to them. Two examples were again used to demonstrate the task to the participants and these examples did not involve any of the pseudowords contained in either of the sets used during the intervention. The timer was started at the same moment that the first pseudoword was read. A new pseudoword was read immediately after the participants had completed the segmenting task for a particular word or had indicated that they were unable to complete the task.

The Adduction 2 pre-tests were conducted over one-minute timings. The task involved the participants hearing a pseudoword and circling the appropriate phonemes in the correct order on a worksheet. The words took approximately 0.5 seconds for the researcher to say and the children were able to begin circling as they listened to the word or after it was said. Thus, the activity was a “hear/mark” task. An example of a worksheet that was not to be used in the Adduction 2 tests was used to demonstrate to the participants the requirements of the task. The researcher read a new pseudoword immediately after the participants had completed circling the phonemes for a particular word.

Phase B: Intervention

The intervention phase commenced when all baseline measures were completed. Participants were randomly assigned the order of whether to begin training in either the RB or the RBAAT condition first or second.

Accurate see/say phonemes were trained through different methods in the RB and RBAAT conditions. In the RBAAT condition an accuracy training stage preceded the rate-building stage. During this stage the participants were taught to read the phonemes with 100% accuracy twice and on two consecutive trials through DI (Direct Instruction) and discrete trial training. Commencement of the rate-building stage was dependent upon the participants’ achievement of these accuracy criteria. However, in the RB condition the participants were given minimal accuracy training before the rate-building exercises commenced. Two phonemes from the set were introduced to the children through the DI procedure and then were immediately involved in the rate-building exercises. There was no accuracy criterion upon which the commencement of the rate-building exercises commenced in the RB condition. The remaining phonemes in the RB set were then taught through the same DI procedure at specific stages in the rate-building schedule, which will be explained in more detail in the section that outlines the DI procedure.

The next section will describe the DI procedure that was used throughout the rate-building procedure to develop minimal accuracy in the RB condition, and which was used in combination with discrete trial training to teach accurate phoneme reading in the RBAAT condition. Following will be a section detailing the accuracy training stage in the RBAAT condition and the rate-building procedure for the RB condition.

Direct Instruction (DI) procedure.

The DI procedure involved choosing a phoneme randomly from the appropriate set and showing it to a participant. The researcher said the sound and the child was then required to say the sound in unison with the researcher. Correction was given if needed and the child repeated the letter or digraph sound. Finally, the child said the sound independently, without prompting or modelling.

The DI procedure was used to initially introduce two phonemes in the RB condition in order for it to be possible for the participants to begin the rate-building exercises. There was no reinforcement available during the DI procedure, except social comments such as, “good try”, and the commencement of rate-building exercises was not dependent upon any accuracy criterion in the RB condition. The DI procedure was utilized at later stages in the rate-building schedule to introduce the remaining phonemes in the set to the children. A new phoneme was introduced each time the participants had completed the rate-building sequence once, immediately prior to beginning the sequence again, until all phonemes were introduced. The rate-building sequence is explained in detail in another section (p. 117).

In the RBAAT condition, the DI procedure was used to train see/say phonemes to 100% accuracy on two consecutive trials for all phonemes. However it was used in combination with discrete trial training as described in the following section.

Accuracy training in the RBAAT condition.

The participants were initially taught two phonemes that were chosen at random from the set allocated to this condition through the DI procedure described previously. They were then involved in discrete trial training. During these trials the participants were shown one of the phonemes they had been taught. The child responded and reinforcement was contingent upon a correct response. If the participant responded incorrectly he or she was corrected using the DI procedure and reinforcement was withheld. There were two examples of each phoneme and the trials were conducted for each example. The children had to respond correctly to each example of the two phonemes (and therefore make four correct responses) before they were taught a new phoneme.

Another phoneme from the set was then introduced through the DI procedure. The two examples of this phoneme were then added to the set previously taught and the children were involved once again in discrete trials training. The participants engaged in discrete trials training after each new phoneme was introduced. When all of the phonemes had been introduced to the children, discrete trials training continued until each child attained 100% accuracy on both examples of all of the phonemes in the set on two consecutive trails. Reinforcement was contingent upon the achievement of higher scores on each set of trials than on the previous set of trials irrespective of the time taken.

Rate-building procedure

The rate-building procedure consisted of rate aims, timed sprints and drills, coaching, feedback, reinforcement and error correction. Rate aims were set at 20 ppm increments. The baseline range comprised a rate aim of 0-20 ppm. During the intervention the first rate aim was 21-41 ppm and these increased in 20 ppm increments. The children were provided with a specific rate aim before the commencement of each timing. When they achieved a particular rate aim they were set the next rate aim, for example 42-62 ppm, before the next timing. Reinforcement was contingent upon attaining a rate aim on a particular timing. When the timings were shorter than one minute in duration, as on the sprints, the rate aims were adjusted accordingly by dividing the number of seconds in the timing by 60 seconds and multiplying by the rate aim for one minute. For example, if the rate aim a participant was attempting to achieve was 20 ppm, but the timing was for 15 seconds, then the rate aim for the 15-second drill would be 5 ppm.

Timed sprints and drills were involved in the rate-building procedure. The sprints were very short 10-second intervals of timed repeated practice. Three 10-second sprints interspersed each drill in the rate-building sequence. There were four types of drills, which increased systematically in increments of 15 in the rate-building sequence. The first drill was a 15-second drill, which was followed by the three 10-second sprints. Next was a 30-second drill after which three 10-second sprints were again scheduled. A 45-second drill followed in the sequence, after which three 10-second sprints again proceeded. Finally, a one-minute drill completed the rate-building sequence. The rate-building sequence is displayed in Figure 4.2. The children completed this sequence once on each day of training in a particular condition.

The participants began the rate-building sequence immediately after the first two phonemes were introduced in the RB condition, and after reaching the accuracy criterion in the RBAAT condition. The appropriate set of phoneme cards allocated for each condition were placed in the same circular arrangement on the children’s desks as was described for

FIGURE 4.2 SHOWING THE RATE BUILDING SEQUENCE

the baseline pre-testing procedure. The participants were informed of the length of the timing and the rate aim to be achieved. The children were told that they were to read as quickly as possible, that they were to continue around the circle of phoneme cards until the timer sounded, and that they would receive a sticker on their chart if they reached the aim. They were told to say, “skip” for any phoneme that they were unable to read. In the same manner as during the baseline testing, the pre-primary participants were reminded how to say the sound of the letters and not the names and the Year 2 participants were shown how to read the digraphs and not the sound of each letter. The timer was then set to measure the specific number of seconds of the particular timing and was started at the same time that the participant was told to begin reading as quickly as possible. The researcher recorded the number of correct and incorrect responses during the timing.

During each timing the participants were provided with coaching in the form of encouraging statements to “go faster” or “keep that speed”. Some of the participants believed they were unable to increase their speeds beyond their current performance levels. In these cases the participants were provided with other types of coaching. For example, it was useful to have the children repeat a sentence as quickly and as many times as they were able in a specific interval to indicate to them how quickly they could in fact “speak”.

Feedback was provided to the participants after each sprint and drill. The participants were told the number of phonemes they had read correctly during the timing and it was indicated whether or not they had achieved the rate aim. Reinforcement was contingent upon reaching or exceeding a specified rate aim for a particular timing. Stickers were placed on their charts on each occasion that they achieved or exceeded their aim. The chart contained five grids which each consisted of ten empty squares. Stickers were placed in the squares. When all ten stickers were in place they were allowed to choose an item from the treasure box.

An error correction procedure was then employed. Errors were always corrected after a timing was completed so as not to disrupt the flow of responses during the timed performance. The error correction procedure was used to indicate any incorrect responses and to provide corrective feedback. It comprised the same DI procedure as was originally used to teach the phonemes.

Phase C: Post-testing

Three days after the termination of the intervention in each condition the short-term retention post-tests were conducted. These followed the same format as the see/say pre-tests that were described in the baseline section. The endurance, VS, AS, CAVS, Application 1, Application 2, Adduction 1 and Adduction 2 post-tests were conducted in random order in the week following the final intervention week. Each of the post-tests was administered in the same manner as the corresponding pre-tests, which were described in the baseline section (pages 112-115).

Phase D: Follow-up testing

Three months after the intervention was completed, the children were involved in follow-up testing to assess the retention of rates on each of the RESAA measures after the three-month period of no practice. The RESAA follow-up tests were also given in random order and in the same manner as the pre-tests and post-tests.

Inter-observer reliability

Inter-observer reliability was assessed during the baseline, intervention, post-test and follow-up phases. The twelve children were randomly assigned to one of four groups so that there were three individuals in each group. These groups were then assigned to one of the experimental phases. The children in each group were videotaped during the experimental phase to which they had been allocated. A second observer then scored the correct responses on each timing from the videotapes. The second observer was previously trained in joint practice sessions with the experimenter using other tapes of sessions.

Group 1 children were assigned to the baseline phase and were videotaped during each of the RESAA pre-tests in both conditions. Group 2 individuals were assigned to the intervention phase. This phase was conducted over an eight-week duration and the children were videotaped for two whole sessions for both conditions in the fourth and eighth weeks of the intervention period. Group 3 children were videotaped as they participated in each of the RESAA post-tests in the two conditions. Group 4 individuals were videotaped on each of the RESAA follow-up tests in the RB and RBAAT conditions.

Inter-observer reliability scores were expressed as the percentage of agreement between the researcher and the second observer. Percentage agreement was calculated by dividing agreement by agreement plus disagreement and multiplying by 100. The mean of the percentage agreements was then calculated for each rate measure and for each phase. The reliability scores are shown in Table 4.3. The reliability scores ranged from 77.8% to 100% with a mean of 94.5% across the four experimental phases.

Table 4.3: Interobserver reliability measures for see/say training rates and RESAA tests in each experimental phase.

Rate Measures	Reliability Scores (% agreement)							
	Baseline Phase		Intervention Phase		Post-test Phase		Follow-up Phase	
	RB	RBAAT	RB	RBAAT	RB	RBAAT	RB	RBAAT
See/say training rates	100	100	87.2	82.8	N/A	N/A	N/A	N/A
Retention	100	100	N/A	N/A	88.6	86.5	93.1	98.5
Endurance	100	100	N/A	N/A	92.0	88.9	91.2	97.6
V. Stability	100	100	N/A	N/A	85.8	91.2	97.5	94.0
A. Stability	100	100	N/A	N/A	78.5	90.2	90.8	97.0
Combined Stability	100	100	N/A	N/A	90.1	81.5	96.3	93.1
Application 1	100	100	N/A	N/A	77.8	86.4	100	93.8
Application 2	100	100	N/A	N/A	88.4	92.9	100	100
Adduction 1	100	100	N/A	N/A	85.7	81.6	92.9	96.9
Adduction 2	100	100	N/A	N/A	96.7	100	100	95.5

CHAPTER 5

RESULTS OF STUDY (1)

The results relating to the Year 2 participants will first be presented in this chapter, followed by the results for the pre-primary children. The chapter will conclude with an overall summary of the data relating to the Year 2 and pre-primary participants. A large quantity of data was obtained from the procedures in Study 1. To maintain cohesion in this chapter, only the see/say training rate data, phoneme practice repetition data and quantities of reinforcement data have been included for each individual. The RESAA results have been summarized as group means and individual participant RESAA data have been included in the appendices. The relevant appendices will be referred to throughout this section as they relate to the findings being described.

Year 2 participant results

Phoneme practice repetitions in the RBAAT and RB conditions

The figures showing accuracy acquisition before rate-building in the RBAAT condition are contained in Appendix 7. Individuals were required to accurately see/say both examples of each phoneme in the set on two consecutive trials to attain the accuracy criterion. The numbers of phoneme practice repetitions that were required for each participant to reach the 100% accuracy criterion in the RBAAT condition were 273, 234, 312, 260 and 284 for Adam, Christine, Jimmy, Karl and Tanya respectively. To maintain accurate responding, the same individuals then received an additional 151, 18, 63, 56, and 86 correction repetitions of the phonemes, respectively, during the error-correction procedure in rate-building stage of the RBAAT condition. In the RB condition, there was no preceding accuracy training stage except the one practice repetition during the initial introduction to each phoneme and then accuracy was acquired and maintained through phonemes correction repetitions during the error-correction procedure involved in the rate-building exercises. Adam, Christine, Jimmy, Karl and Tanya required a total of 82, 40, 89, 100 and 143 phoneme repetitions to acquire and maintain accuracy in the RB condition.

Figure 5.1 shows for each child a) the combined number of initial practice repetitions that were required to introduce each phoneme and number of phoneme correction repetitions each participant received during rate-building in the RB condition and b) the combined number of phoneme practice repetitions required to reach the 100% accuracy criterion and correction repetitions that they then received during rate building in the RBAAT condition. All participants required a far greater number of phoneme repetitions in the RBAAT condition than in the RB condition to acquire and sustain accuracy. The mean number of phoneme repetitions for the RB condition was 90.8 (SD = 33.1) and for the RBAAT condition it was almost four times greater at 347.4 (SD = 58.7). The Wilcoxon matched-pairs signed-ranks test (Siegel, 1956) revealed a statistically significant difference ($T = 0$, $p<0.05$) between the two conditions.

See/say training rates for the Year 2 participants

The rate-building exercises employed in the two conditions followed the sequence that was illustrated in Figure 4.2 (p. 119). The focus of the see/say training rates was on the one-minute timings, whereas the shorter sprints and drills were used to build rates in successive approximations. Therefore, only the data yielded from the one-minute timings are included

FIGURE 5.1: PHONEME REPS FOR YEAR 2S

in the figures and data analyses contained in this chapter. The development of correct and incorrect see/say rates on the one-minute timings are shown for each participant in the two conditions in Figures 5.2 to 5.6. The phases labeled "A" are the baseline phases, "B" are the intervention phases, "C" are the post-test phases and "D" are the follow-up phases. The general trend in data was common across all five Year 2 participants, although some children progressed faster and achieved higher rates than others.

The baseline correct see/say rates for all participants across both conditions was 0 ppm. Each participant demonstrated marked increases in correct see/say rates on the first one-minute timing of the intervention phase in the RB condition after the rate-building exercise sequence had been completed only once. Rates increased from zero to 22 ppm, 30 ppm, 19 ppm, 25 ppm, and 26 ppm for Adam, Christine, Jimmy, Karl and Tanya respectively. The increasing trend in correct see/say rates in the RB condition continued across the intervention phase for all participants. The highest single correct see/say rate achieved in the RB condition by each participant was 77 ppm, 70 ppm, 101 ppm, 79 ppm and 56 ppm (for Adam, Christine, Jimmy, Karl and Tanya).

Improvements in correct see/say rates were also evident in the RBAAT condition during the rate-building exercises that were introduced after the accuracy criterion had been achieved by each of the participants. However, the first one-minute timing in the RBAAT condition revealed that the majority of participants' correct see/say rates were lower than those recorded on the first one-minute timing in the RB condition, even after training to 100% accuracy on two consecutive trials in the former condition. Correct see/say rates increased from 0 ppm at baseline to 16 ppm, 24 ppm, 24 ppm and 15 ppm for Adam,

FIGURES 5.2 TO 5.6 TRAINING RATES FOR YR 2'S

Christine, Karl and Tanya respectively on the first one-minute timing in the RBAAT condition. The exception was Jimmy who did demonstrate a higher RBAAT correct see/say rate of 48 ppm compared to his rate of 19 ppm on the first timing in the RB condition. Correct see/say rates also continued to increase over the intervention period for all participants in the RBAAT condition. The highest single correct rate achieved by each of the participants in this condition was 43 ppm, 41 ppm, 71 ppm, 61 ppm and 35 ppm for Adam, Christine, Jimmy, Karl and Tanya respectively. These rates were lower than in the RB condition for each of the five participants.

The highest single correct see/say rates each participant achieved in the RB condition and in the RBAAT condition were used to calculate a group mean see/say training rate for each condition. The group mean see/say rate for the RB condition was 76.6 (SD = 14.6), which was considerably higher than the group mean see/say rate for the RBAAT condition of 50.2 (SD = 13.5). The Wilcoxon matched-pairs signed-ranks test revealed a statistically significant difference ($T = 0$, $p<0.05$) between the two conditions.

Incorrect see/say rates ranged from 15 ppm to 46 ppm in the RB condition on the baseline timings. Immediate decreases in incorrect see/say rates were manifested after the introduction of the rate-building exercises in the RB condition. Incorrect see/say rates decreased by 20 ppm, 10 ppm, 6 ppm, 34 ppm and 6 ppm for Adam, Christine, Jimmy, Karl and Tanya respectively from the baseline phase to the first timing in the RB condition. These rates continued to decrease to near zero levels over the intervention phase in this condition.

The RBAAT incorrect see/say rates ranged from 13 ppm to 55 ppm on the baseline one-minute timings. In this condition, two participants actually showed rapid increases in incorrect see/say rates from the baseline phase to the first timing as shown in Figures 5.2 and 5.5. Even though Adam and Karl could see/say both examples of each of the phonemes with 100% accuracy on two consecutive trials, the introduction of timed performance produced increases in incorrect see/say rates that were almost five times higher than during the baseline phase for Adam and more than twice as high as during the baseline phase for Karl. Moreover, these incorrect see/say rates remained higher than those recorded during the baseline phase for the next three timings for Adam and for the next two timings for Karl before declining to rates lower than those recorded on the baseline timings. For the remaining three children the introduction of the rate-building exercises in the RBAAT condition resulted in decreases in incorrect see/say rates to levels similar to those in the RB condition.

Group mean incorrect see/say rates were calculated over the entire intervention period for each condition. The group mean incorrect see/say rate for the RB condition during the intervention was 8.0 (SD = 2.5) which was slightly lower than the group mean incorrect see/say rate for the RBAAT condition of 8.9 (SD = 5.1) during the intervention period. There was no significant difference between the two conditions ($T = 7$, $p > 0.05$).

Rates on the RESAA pre-tests and post-tests for the Year 2 participants

The figures showing individual participant pre-tests, post-test and follow-up data rates on each of the endurance, stability, application and adduction measures are included in Appendix 8 (Figures 10.1 to 10.8). These data, plus the short-term see/say retention rate data and the correct see/say training rate data that were described in the previous section have been summarized in Table 5.1.

Table 5.1: Summary of the Year 2 participant results for the see/say training rates and RESAA tests

Rate Measure	Mean group rate		SD		Proportion of participants with higher rates in each condition		Wilcoxon *T* score and levels of significance
	RB	RBAAT	RB	RBAAT	RB	RBAAT	
Correct see/say phonemes	76.6	50.2	14.6	13.5	5 of 5	0 of 5	0 ($p<0.05$)
Short-term retention	66.0	53.8	23.9	26.4	4 of 5	1 of 5	2.5 (NSD)
Endurance	61.1	45.1	21.6	22.0	5 of 5	0 of 5	0 ($p<0.05$)
Visual Stability (VS)	70.2	45.8	22.8	28.5	5 of 5	0 of 5	0 ($p<0.05$)
Auditory Stability (AS)	71.8	48.4	22.7	26.1	5 of 5	0 of 5	0 ($p<0.05$)
Combined auditory/visual stability (CAVS)	70.2	46.8	26.4	24.8	4 of 5	1 of 5	1 (NSD)
Application 1	22.8	18.8	7.1	3.7	4 of 5	1 of 5	1.5 (NSD)
Application 2	11.6	9.6	3.4	6.4	4 of 5	1 of 5	2.5 (NSD)
Adduction 1	26.0	18.0	14.0	6.6	4 of 5	1 of 5	2 (NSD)
Adduction 2	8.8	8.0	0.98	4.6	3 of 5	2 of 5	6 (NSD)
Total					43/50 (86%)	7/50 (14%)	

The participants demonstrated 0 ppm rates on most of the RESAA pre-tests. Participants' correct rates on each of the RESAA post-tests (Appendix 8) were used to calculate mean group rates for each of the RESAA measures. Table 5.1 shows the proportion of students who performed at rates that were higher in either the RB or RBAAT condition for each rate measure. The Wilcoxon *T* scores and their levels of significance between conditions are shown in Table 5.1. The letters NSD indicate the cases for which there were no significant differences.

Most of the RESAA post-tests were administered in the week following the termination of the intervention. The short-term retention post-tests were conducted after a three-day period of no practice. The short-term see/say retention rate data are shown in Figures 5.2 to 5.6 in the Phase C following the intervention phase. Jimmy demonstrated increases in see/say rates on the retention post-tests from his highest correct see/say intervention rates in both conditions. Similarly, Christine also showed an increase in her see/say rate on the retention post-test for the RBAAT condition compared to her highest correct see/say training rate in the this condition. Adam and Christine also demonstrated maintenance of their RB see/say rates from the final timing in the intervention period to the post-tests. The remaining participant data indicated decreases in see/say rates on the retention post-tests from the intervention phase.

For the correct see/say training rates and all RESAA post-tests, the group mean rates were consistently higher in the RB condition than in the RBAAT condition. More specifically, Table 5.1 shows that all five participants achieved a higher correct see/say training rate in the RB condition than in the RBAAT condition. Similarly, each of the children generally demonstrated higher correct rates on the RESAA post-test in the RB condition. The total proportion of participants achieving higher rates in the RB condition across all rate measures was 86% compared to only 14% in the RBAAT condition. Despite the small numbers, significant differences between the rates in the two conditions were found for four of the rate measures.

Rates on the RESAA follow-up tests for the Year 2 participants

Three months after the termination of the intervention the participants' rates on the RESAA tests were again assessed in both conditions. The see/say training rate retention tests conducted at this time were long-term retention tests over three months, as opposed to the short-term retention tests which were shown in Table 5.1.

The long-term see/say training retention rates are shown in Figures 5.2 to 5.6 in Phase D on each graph. All participants showed decreases in correct see/say rates in both conditions from the retention post-tests to the follow-up tests. However, Christine demonstrated a correct see/say rate that was only 1 ppm lower on the retention follow-up test than on the post-test in the RB condition, indicating she had retained her rate in this condition after three months. Three of the participants had higher retention rates in the RB condition than in the RBAAT condition on the follow-up tests. The remaining two children had higher retention rates in the latter condition on the same tests.

Follow-up data for individual participants on the endurance, stability, application and adduction measures are shown in Figures 10.1 to 10.8 in Appendix 8. These data have been summarized and are shown in Table 5.2 in this section. The group mean rates were higher in the RB condition than in the RBAAT condition for six of the nine measures. Each of the stability tests revealed group mean rates that were higher in the RBAAT condition, although they were only slightly higher with differences between the means for the two conditions ranging from 1.8 to 3.8. The total proportion of participants with higher rates in the RB condition across rate measures on the follow-up tests was 60% compared to only 27% for the RBAAT condition. The asterisks in Table 5.2 indicate cases in which participants demonstrated the same see/say rates in both conditions (13%). There were no

Table 5.2: Summary of Year 2 participant rates on the long-term RESAA follow-up tests

Rate Measure	Mean group rate		SD		Proportion of participants with higher rates in each condition		Wilcoxon *T* score and levels of significance
	RB	RBAAT	RB	RBAAT	RB	RBAAT	
Long-term retention	31.4	11.8	21.7	11.7	4 of 5	1 of 5	3 (NSD)
Endurance	31.2	14.9	19.8	12.2	3 of 5	2 of 5	4 (NSD)
Visual Stability (VS)	26.0	27.8	20.9	19.0	2 of 5	3 of 5	7.5 (NSD)
Auditory Stability (AS)	25.2	29.0	19.6	22.0	2 of 5	3 of 5	6 (NSD)
Combined auditory/ visual Stability (CAVS)	25.0	26.8	20.7	21.0	2 of 5	3 of 5	5 (NSD)
Application 1	19.4	6.0	12.8	6.7	3 of 5	0 of 5*	0 p<0.05
Application 2	12.2	4.0	10.5	6.1	4 of 5	0 of 5*	0 p<0.05
Adduction 1	32.0	13.2	19.7	13.4	5 of 5	0 of 5	0 p<0.05
Adduction 2	9.6	6.8	5.7	4.1	2 of 5	0 of 5*	0 p<0.05
Total					27/45 (60%)	12/45 (27%)	

significant differences found between the two conditions for five of the rate measures conducted at follow-up. However, for the Application 1 and 2 and for the Adduction 1 and 2 tests a significant difference ($T = 0$, $p<0.05$) was found between the RB and RBAAT conditions.

Quantities of reinforcement in the RB and RBAAT conditions

The quantities of reinforcement (number of contingent reinforcer presentations) in the two conditions were recorded and then tallied for each of the Year 2 participants. These data are shown in Figure 5.7. There were a greater number of reinforcer presentations in the RBAAT condition than in the RB condition for each of the five children. The differences between the reinforcement quantities in the two conditions ranged from two to 18.

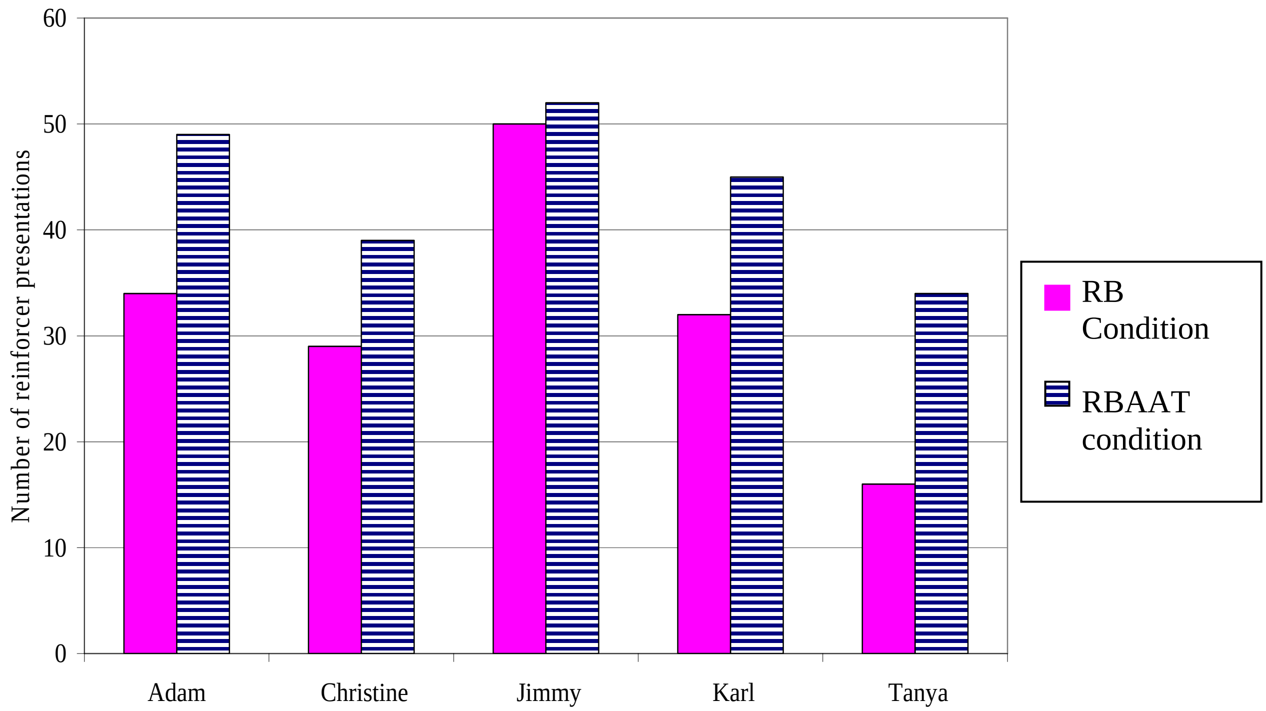

Figure 5.7: Quantities of reinforcement in the RB and RBAAT conditions for the Year 2 participants

Pre-primary participant results

Phoneme practice repetitions in the RBAAT and RB conditions

Figures 11.1 to 11.7 in Appendix 9 show the acquisition of accuracy by each of the participants before rate-building commenced. The total numbers of phoneme practice repetitions that were required for Bryce, Elena, Jake, Leon, Martin and Renee to reach the accuracy criterion were 118, 107, 280, 138, 10, 91 and 267 respectively. These participants then required an additional 40, 13, 44, 121, 8, 24 and 14 phoneme correction repetitions to maintain accuracy during rate-building in the RBAAT condition. In the RB condition there was no preceding accuracy training stage and the children received only one practice repetition to initially introduce each phoneme and then phoneme correction repetitions during the rate-building exercises. Bryce, Elena, Jake, Leon, Martin and Renee required a total of 93, 101, 234, 146, 60, 136 and 107 phoneme correction repetitions to acquire and maintain accuracy in the RB condition.

Figure 5.8 shows a) the combined number of initial practice and number of correction repetitions of phonemes each participant received during the rate building procedure in the RB condition and b) the combined number of phoneme practice repetitions each participant first required to reach the accuracy criterion and number of correction repetitions that they then received during the rate-building stage in the RBAAT condition. Six of the seven participants received a greater number of phoneme repetitions in the RBAAT condition than in the RB condition. Alternatively, Renee received 21 more phoneme repetitions in the RB condition than in the RBAAT. The mean numbers of phoneme repetitions for the RB condition was 125.3 (SD = 51.5) and for the RBAAT

FIGURE 5.8: PHONEME REPETITION FOR PRE'S

condition it was 195 (SD = 83.8). The Wilcoxon matched-pairs signed-ranks test revealed a significant difference between the two conditions ($T = 2$, $p<0.05$).

See/say training rates for the pre-primary participants

The development of correct and incorrect see/say training rates in both conditions for each participant is shown in Figures 5.9 to 5.15. The phases labeled “A” are the baseline phases, “B” are the intervention phases, “C” are the post-test phases and “D” are the follow-up phases.

The baseline correct see/say rates for all seven pre-primary participants was 0 ppm in the RB condition. Immediate increases in correct see/say training rates were observed after the introduction of the rate building exercises in this condition. Bryce, Jake, Leon, Renee and Reece showed small increases in correct see/say rates from their baseline rates of 0 ppm to 7 ppm, 10 ppm, 8 ppm, 4 ppm and 4 ppm on the first one-minute timing in the intervention phase respectively. Elena and Martin showed much higher increases in correct see/say training rates from the baseline rates of 0 ppm to 21 ppm and 26 ppm on the first timing in the RB condition. An increasing trend in correct see/say rates continued across the intervention phase in this condition. The highest single correct see/say rate that was achieved by each child in the RB condition during the intervention phase was 33 ppm, 65 ppm, 23 ppm, 37 ppm, 52 ppm, 33 ppm, 47 ppm for Bryce, Elena, Jake, Leon, Martin, Renee and Reece respectively.

All participants performed at baseline correct see/say rates of 0 ppm in the RBAAT condition. Rapid increases to 17 ppm, 40 ppm, 27 ppm, 44 ppm, 18 ppm and 23 ppm were

FIGURES 5.9-5.15: SEE/SAY TRAINING RATES FOR PRES

evident for Bryce, Elena, Jake, Martin, Renee and Reece respectively on the first intervention timing, which in the RBAAT condition came after a number of trials of accuracy training alone. Leon showed a much smaller increase from his 0 ppm baseline correct see/say rate to 9 ppm on his first intervention timing. As in the RB condition, correct rates continued to increase across the intervention period in the RBAAT condition. The highest single correct see/say training rates attained by each of the participants in the RBAAT condition were 38ppm, 68 ppm, 30 ppm, 31 ppm, 58 ppm, 53 ppm and 38 ppm for Bryce, Elena, Jake, Leon, Martin, Renee and Reece correspondingly.

The highest single correct see/say training rates that each participant attained on the one-minute timings in the RB condition and in the RBAAT condition were used to calculate a group mean intervention rate for each condition. For the RB condition the group mean correct see/say training rate was 41.4 ($\underline{SD}$ = 13.1), which was slightly lower than the group mean training rate for the RBAAT condition of 45.1 ($\underline{SD}$ = 13.5). The Wilcoxon matched-pairs signed-ranks test revealed no significant difference between the conditions ($T = 7.5$, $p>0.05$).

Baseline incorrect see/say rates in the RB condition ranged from 4 ppm to 73 ppm. Decreases in incorrect see/say rates for five of the seven participants were evident after the commencement of the rate building exercises in the RB condition. However, Jake's incorrect see/say training rate actually increased from 36 ppm at baseline to 41 ppm on the first intervention timing. Similarly, Reece demonstrated an increase in incorrect see/say rate from 4 ppm during the baseline phase to 11 ppm on the first intervention timing in the RB condition. Nonetheless, decreasing trends in incorrect see/say rates were evident for all children across the period of intervention in the RB condition.

In the RBAAT condition the baseline incorrect see/say rates ranged from 11 ppm to 72 ppm. Even though all of the participants had first reached the 100% accuracy criterion on two consecutive trials, the commencement of the rate-building exercises in the RBAAT condition coincided with increases in incorrect see/say rates on the first intervention timing for all but one of the participants. Incorrect see/say rates increased to as high as 22 ppm for Leon on the first timing in the RBAAT condition after 21 trials of accuracy training alone. However, decreasing trends in incorrect see/say rates were observed across the intervention period for five of the participants in the RBAAT condition. Conversely, Jake and Martin showed very slight increasing trends in incorrect see/say rates during the intervention phase in the RBAAT condition.

The mean group incorrect see/say rate during the intervention period for the RB condition was 4 (SD = 2.2), which was slightly higher than the group intervention mean for the RBAAT condition of 2.5 (SD = 0.9). There was a significant difference between the two conditions ($T = 0$, $p < 0.05$).

Rates on the RESAA pre-tests and post-tests for the pre-primary participants

All participants demonstrated 0 ppm rates on each of the RESAA pre-tests. The post-test short-term retention rates, that were conducted three says after the completion of the intervention phase, are shown in Figures 5.9 to 5.15 in Phase C following the intervention phase. Some of the children demonstrated even higher see/say rates on the retention post-tests than during the intervention phase. Elena, Martin and Reece demonstrated increases in see/say rates from their highest see/say training rates during the intervention period in the RB condition on the retention post-tests. Bryce, Martin and Reece showed similar increases in see/say rates on the retention post-tests from the rates they had achieved during the intervention period in the RBAAT condition. Elena's RBAAT post-test retention rate was higher than her see/say training rate on the final timing in the intervention period for the RBAAT condition but did not exceed her highest see/say training rate attained during the treatment phase. The remaining children showed decreases in see/say rates from the intervention period to the retention post-tests.

The figures that show individual participant pre-test, post-test and follow-up test data for the endurance, stability, application and adduction outcomes are included in Appendix 10. The post-test data and the short-term retention rate and see/say training rate data described previously have also been summarized in Table 5.3. As with the Year 2 data, participant rates on each of the RESSA post-tests were used to calculate a mean group rate for each RESAA outcome. Table 5.3 also shows the proportion of children that performed at rates that were higher in either the RB or RBAAT conditions for each rate measure. The Wilcoxon *T* scores and their levels of significance between conditions are also shown in the table.

The mean group rates were higher in the RBAAT condition than in the RB condition for correct see/say training rates and most RESAA tests. However, there was often very little difference between the rates in the two conditions. Only the group mean for the Application 1 post-test was higher in the RB condition than in the RBAAT condition, although the difference between the means was again only small. Table 5.3 shows that five of the participants attained a higher correct see/say training rate in the

Table 5.3: Summary of the Pre-primary participant results for the see/say training rates and RESAA tests

Rate measure	**Mean group rate**		**SD**		**Proportion of participants with higher rates in each condition**		**Wilcoxon T scores and levels of significance**
	RB	RBAAT	RB	RBAAT	RB	RBAAT	
Correct see/say phonemes	41.4	45.1	13.1	13.5	2 of 7	5 of 7	7.5 NSD
Short-term retention	42.0	42.9	25.9	18.0	3 of 7	4 of 7	15 NSD
Endurance	31.9	37.9	16.5	13.8	2 of 7	4 of 7	3 NSD
Visual Stability (VS)	31.3	35.7	16.1	12.9	2 of 7	5 of 7	1.5 ($p<0.025$)
Auditory Stability (AS)	30.4	36.0	14.5	14.8	2 of 7	5 of 7	3 NSD
Combined Auditory/Visual Stability (CAVS)	29.6	37.1	16.9	18.1	1 of 7	6 of 7	5 NSD
Application 1	31.3	30.4	19.0	23.2	3 of 7	3 of 7	6 NSD
Application 2	7.4	9.6	10.2	10.6	2 of 7	3 of 7	4.5 NSD
Adduction 1	20.6	22.4	17.4	17.2	2 of 7	4 of 7	7 NSD
Adduction 2	4.6	5.9	3.9	5.6	2 of 7	4 of 7	4 NSD
	Total				21/70 (30%)	39/70 (56%)	

RBAAT condition than in the RB condition. The table also shows that a greater proportion of the participants generally achieved higher rates in the RBAAT condition on each of the RESAA post-tests. Overall, the total proportion of participants that achieved higher correct rates in the RBAAT condition across all rate measures was 56% compared to only 30% in the RB condition (14% had similar scores in the two conditions). However, significant differences between the rates in the two conditions were found only for the VS post-tests.

Rates on the RESAA follow-up tests for pre-primary participants

Three months after the intervention was completed the participants' rates on each of the RESAA tests were again assessed in both conditions. The follow-up retention rate data are shown in Figures 5.9 to 5.15 in Phase D on each graph. Most participants showed large decreases in see/say rates from the retention post-tests to the follow-up retention tests in both conditions. The exceptions were Leon and Martin who actually had higher see/say rates on the follow-up retention tests than on the post-tests in the RBAAT condition. Moreover, these rates also exceeded their highest correct see/say training rates in the intervention phase, indicating they had maintained or increased their intervention rates over the three months in the RBAAT condition.

The follow-up data have been summarized in Table 5.4. There were only six of the original seven participants available for follow-up testing as one child had transferred to a school in another state. The mean group rates were higher in the RB condition for six of the nine follow-up measures. However, these mean group rates were often only slightly higher than in the RBAAT condition, with differences between the means for the two conditions ranging from 0.2 to 4.3. The retention and Adduction 2 mean group rates were higher in the RBAAT condition than in the RB condition, although the differences between the two conditions of only 2.6 and 0.8 were also very small. The Application 2 mean group rates were equal at 0.

Table 5.4: Summary of the Pre-primary participant results for the follow-up RESAA tests

Rate measure	**Mean group rate**		**SD**		**Proportion of participants with higher rates in each condition**		**Wilcoxon T scores and levels of significance**
	RB	RBAAT	RB	RBAAT	RB	RBAAT	
Long-term retention	17.2	19.8	16.9	22.6	2 of 6	4 of 6	6 NSD
Endurance	18.2	17.9	17.0	20.0	4 of 6	2 of 6	9 NSD
Visual Stability (VS)	23.0	19.2	26.8	20.7	2 of 6	4 of 6	8.5 NSD
Auditory Stability (AS)	24.5	20.2	27.4	20.9	3 of 6	3 of 6	9.5 NSD
Combined Auditory/Visual Stability (CAVS)	21.7	17.2	24.0	16.6	2 of 6	3 of 6	6.5 NSD
Application 1	17.2	17.0	24.4	23.0	1 of 6	3 of 6	4 NSD
Application 2	0	0	0	0	0 of 6	0 of 6	0 NSD
Adduction 1	21.0	17.7	18.0	13.2	3 of 6	3 of 6	7 NSD
Adduction 2	3.5	4.3	2.4	4.4	3 of 6	3 of 6	8 NSD
	Total				20/54 (37%)	25/54 (46%)	

There were varied results concerning the proportions of participants that performed at rates that were higher in a particular condition. The total proportion of participants that attained higher rates across the RESAA measures was greater for the RBAAT condition at 46% than for the RB condition at 36%. However, the difference between these proportions was again only small. There were no significant differences found between the RB and RBAAT conditions for any of the rate measures at follow-up.

Quantities of reinforcement in the RB and RBAAT conditions for the pre-primary participants.

The quantities of reinforcement (i.e., number of contingent reinforcer presentations) in the RB and RBAAT conditions for each participant were tallied. These data are shown in Figure 5.16. There were more instances of reinforcement in the RBAAT condition than in the RB condition for each of the pre-primary children. Differences between the reinforcement quantities in each condition ranged from three to 17.

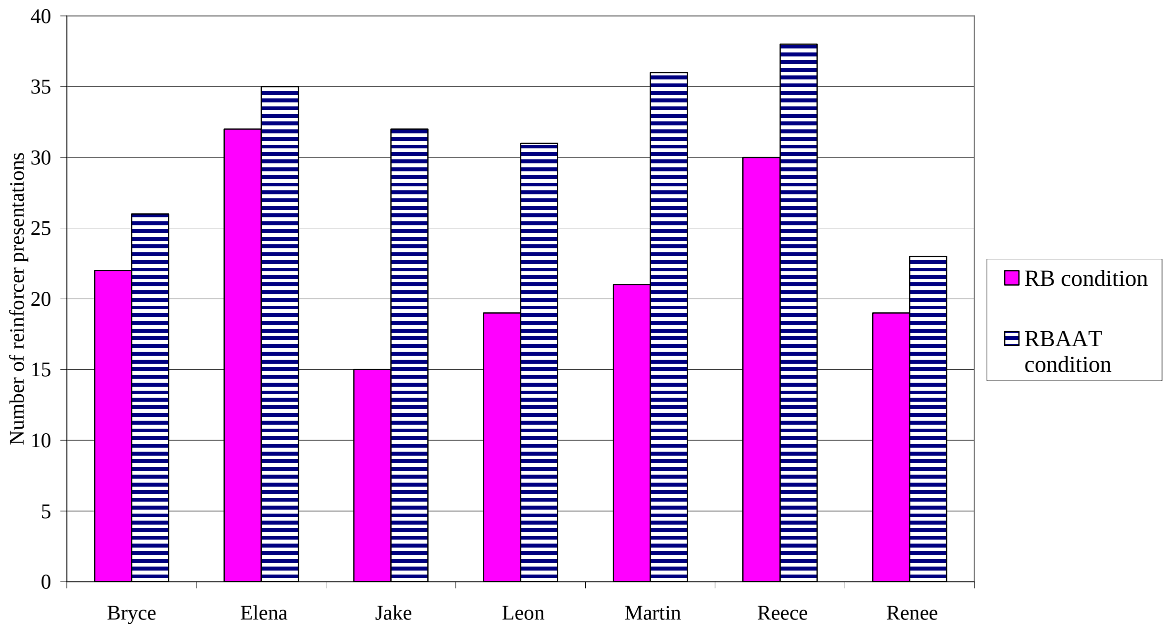

Figure 5.16: Quantities of reinforcement in the RB and RBAAT conditions for the pre-primary participants

Overall summary of results

The results have shown that, generally, a greater number of phoneme repetitions were required to acquire and maintain accuracy in the RBAAT condition than in the RB condition. All five Year 2 participants and six of the seven pre-primary children required more phoneme repetitions in the RBAAT condition. The mean number of phoneme repetitions in the RBAAT condition was almost four times greater than the mean number of repetitions in the RB condition for the Year 2 group. For the pre-primary group, the mean number of phoneme repetitions in the RBAAT condition was almost 1.5 times greater than in the RBAAT condition.

Both conditions produced increases in the correct see/say phoneme training rates for each participant on the one-minute timings for the Year 2 and pre-primary groups. However, more rapid increases in correct see/say training rates were generally evident in the RB condition than in the RBAAT condition for the Year 2 participants. On the other hand, the pre-primary participants generally demonstrated more immediate increases in correct see/say training rates in the RBAAT condition than in the RB condition.

The mean group correct see/say training rate was higher for the Year 2 participants in the RB condition than in the RBAAT condition and the difference was statistically significant. A far greater proportion of participants performed at rates that were higher in the RB condition than in the RBAAT condition across the rate measures. Conversely, the mean group correct see/say training rate for the pre-primary participants was slightly higher in the RBAAT condition than for the RB condition, although the difference was very small and not statistically significant. A greater proportion of the pre-primary participants performed at rates that were higher in the RBAAT condition than in the RB condition, although the difference between these proportions was not as large as the difference between the Year 2 proportions.

Immediate decreases in incorrect see/say rates were observed in the RB condition for the Year 2 participants. Similarly, most of the pre-primary participants' incorrect see/say rates showed immediate decreases in the RB condition. However, two of the pre-primary participants' incorrect see/say rates actually increased slightly before declining in this condition. In the RBAAT condition two of the five Year 2 participants' incorrect see/say rates increased with the introduction of the rate-building exercises even though these participants had reached the 100% accuracy criterion on two consecutive trials before the rate-building exercises commenced. All but one of the pre-primary participants' incorrect see/say rates also increased with the introduction of the rate building exercises after a number of trials of accuracy training alone. However, incorrect see/say rates eventually declined to low levels of below 10 ppm for all participants across the period of intervention in both conditions.

RESAA post-tests revealed consistently higher mean group rates in the RB condition than in the RBAAT condition for the Year 2 participants. For the pre-primary participants the reverse was generally observed, although the differences between the mean group rates in each condition were very small for this group of children.

A Wilcoxon matched-pairs signed-ranks test was used to ascertain whether the see/say training rates and RESAA rates for the Year 2 and pre-primary participants differed significantly. A significant difference was found between the Year 2 and pre-primary rates for the RB condition ($T = 4$, $p < 0.01$) and the Year 2 participants demonstrated superior results compared to the pre-primary children. However, no significant difference was found between the Year 2 and pre-primary rates in the RBAAT condition ($T = 13$, $p > 0.25$).

Follow-up data revealed that mean group rates were higher in the RB condition than in the RBAAT condition for six of the nine RESAA measures for both the Year 2 and pre-primary participants. The three RESAA measures for which the mean rates were higher in the RBAAT condition differed for the Year 2 and pre-primary participants. The CAVS, AS and VS group means were higher in the RBAAT condition for the Year 2 children. For the pre-primary participants, the group means were higher in the RBAAT condition for retention and Adduction 2 measures. For the Application 2 measures the means were zero in both conditions. The Year 2 children demonstrated significantly higher rates than the pre-primary children on the follow-up tests in the RB condition ($T = 0$, $p < 0.005$). However, there was no significant difference between the Year 2 and pre-primary participant rates on the follow-up tests in the RBAAT condition ($T = 20$, $p > 0.025$).

Participants were first reinforced for correct responses on discrete trials only in the RBAAT condition during accuracy training. They were then reinforced for accuracy and speed during the rate-building exercises in this condition. In the RB condition reinforcement was contingent only upon building higher correct rates. Tallies indicated that the quantities of reinforcement required to acquire and maintain accuracy were higher in the RBAAT condition than in the RB condition for all of the Year 2 and the pre-primary participants.

In conclusion, superior results were evident in the RB condition than in the RBAAT condition for the Year 2 participants. Moreover, the instructional method employed in the RB condition was more economical in terms of the quantities of practice and reinforcement required to produce these results. Thus, for the Year 2 participants, training accuracy and rate was far more efficient and produced higher see/say phoneme rates and higher rates on most RESAA tests (86%) than training 100% accuracy and then building rate in a two-stage process. Conversely, slightly superior results were generally produced in the RBAAT condition than in the RB condition for the pre-primary participants, although more reinforcement and phoneme repetitions were also required to produce these results. However, the differences between the performances of the pre-primary participants in the two conditions was minimal in comparison to the more pronounced differences that were apparent between the Year 2 participants’ performances in the two conditions.

CHAPTER 6

DISCUSSION FOR STUDY (1)

A discussion of the results specific to Study 1 is presented in this chapter. First, the findings of the study are examined in relation to the pre-primary and Year 2 participants as two separate groups. The research questions labeled one to six on page 95 are addressed in these sections. Next, comparisons are made between the Year 2 and pre-primary results and the discussion relates to the seventh research question. Following is a conclusion and some implications for future research. A general discussion related to both Studies 1 and 2 is presented in Chapter 10.

See/say training rates

Year 2 results

Each of the children in the Year 2 group demonstrated 0 ppm correct rates on the one-minute baseline tests in the RB and RBAAT conditions. These measures showed that the children were unable to accurately see/say any of the phonemes prior to the intervention in either condition. The instructional procedures employed in both conditions were successful in producing increases in correct see/say training rates for each of the Year 2 children involved in the study. However, superior see/say training rates were attained in the RB condition compared to the RBAAT condition for all of these participants. The results indicated that training the children to 100% accuracy before implementing rate-building exercises did not influence the achievement of higher correct see/say rates on the one-minute timings during training. In fact, the students were able to attain significantly higher correct training rates, over an equal time period, when accuracy and rate were trained simultaneously. These findings are consistent with Lindsley's (1996a) reports of practitioner evidence indicating that steeper accelerations in performance rates were observed when speed was emphasized over accuracy.

The lower see/say training rates in the RBAAT condition may have been attributable to the preliminary emphasis on accuracy. Some researchers have suggested that an initial focus on accurate responding may impede the rate-building process as learners become overly cautious and fearful of making mistakes (Samuels, 1997; Binder, 1990b; Lindsley, 1996a). In the RBAAT condition, accurate responses were reinforced before rate-building exercises were introduced. Thus, the participants were aware that they had attained 100% accuracy on two consecutive trials for the set of phonemes allocated to the RBAAT condition before they began rate-building. Although speed was then reinforced during the rate-building exercises in this condition, the children may have hesitated more frequently to recall particular phonemes that they were aware they “knew” but that they were unable to immediately say, compared to in the RB condition in which the emphasis was always on speed. Such hesitation would have the effect of slowing the children’s correct rates on the one-minute timings in the RBAAT condition.

The one-minute timings that were conducted during the baseline phase with the Year 2 children showed high incorrect rates for most participants. For each child the baseline error rates in one condition were often significantly higher than the incorrect rates in the other condition. The differences in baseline error rates between the two conditions could be attributed to sequencing effects in the experimental design. Sequence effects occur when the participants’ experiences in one condition affect their responses in another condition (Graziano & Raulin, 1997). The sets of phonemes were randomly assigned to conditions for each of the participants, and each child was also randomly assigned to begin baseline testing in a particular condition to counterbalance carry-over effects (Goodwin, 1995). However, it was observed that for each child higher incorrect rates were demonstrated for the second set of phonemes that were assessed, suggesting there were possibly carry-over effects. On the timing for the first set of phonemes, the participants hesitated frequently and attempted to read each phoneme at the beginning of the time interval. As the timing progressed, however, and they became aware that they were unable to read the phonemes, they said, “skip” at progressively higher speeds and gradually ceased to even attempt to read the phonemes. When the second set of phonemes was assessed, the participants made far fewer attempts to read the phonemes and often resorted to saying, “skip”, in the first few seconds of the timing. Thus, learning to say “skip”, combined with the prior experience of failure in reading the first set of phonemes was likely to have affected the higher incorrect rates on the second set of phonemes during the baseline phase.

The procedures employed in the RB and RBAAT conditions produced decreases in incorrect rates during training for each of the Year 2 children over the intervention phase. When the incorrect rates in the RB were compared to the incorrect rates in the RBAAT condition post accuracy training, the rates were very similar for Christine and Jimmy for the remainder of the intervention period. Therefore, both training to 100% accuracy before rate building and allowing accuracy and rate to develop simultaneously were equally efficacious procedures for reducing the error rates of these two children over an equal time period. For Adam and Karl, the incorrect rates in the RB and RBAAT conditions, post accuracy training in the RBAAT condition, were lower in the RB condition for a number of timings before the rates in the two conditions became similar. Thus, for these two children, allowing the simultaneous development of accuracy and rate was more effective, over an equal period of time, in decreasing incorrect rates than first training accuracy to 100% before rate-building. Only Tanya demonstrated lower incorrect rates in the RBBAT condition than in the RB condition during post accuracy training in the former condition. However, after two timings her rates in the two conditions were comparable. The group mean incorrect rates for the Year 2 children in the two conditions were relatively similar, although the mean for the RB condition was slightly lower than for the RBAAT condition. Overall, these results showed that the RB training procedure was either the slightly more efficacious means of decreasing the incorrect see/say phoneme rates or was of comparable efficiency to the RBAAT training procedure.

The RB training procedures produced a higher group mean correct training rate and a lower group mean incorrect rate than the instructional methods in the RBATT condition. Additionally, all five children attained a higher correct training rate in the former condition. Thus, for the Year 2 children, the RB instructional procedures were more efficient in training see/say phoneme rates than the RBAAT procedures over an equal period of time. It was concluded that training accuracy and rate simultaneously was a more effective method of training see/say phoneme rates than training the participants to 100% accuracy before attempting to build rate.

Pre-primary results

The one-minute timings conducted with the pre-primary children in the baseline phase showed that each of the children were unable to identify any of the phonemes prior to the commencement of the intervention. All demonstrated correct rates of 0 ppm on these measures. The methods of instruction applied in both the RB and RBAAT conditions produced increases in correct see/say training rates for each of the pre-primary children.

However, five out of the seven children attained higher correct see/say training rates in the RBAAT condition than in the RB condition, a finding that contrasted the results for the Year 2 participants. Thus, for most of the pre-primary children, training the phonemes to 100% accuracy before beginning the rate-building exercises was more beneficial than training accuracy and rate simultaneously. These results are consistent with recommendations of other researchers who have advised that accuracy should be achieved before attempting to build rate (Kuhn & Stahl, 2003; Binder, 1996; Meyer & Felton, 1999; Howell & Howell, 1990; Howell & Morehead, 1987; White & Haring, 1980).

Two of the pre-primary individuals, however, attained higher see/say training rates in the RB condition compared to in the RBAAT condition. This indicated that for these children, at least, there was no advantage in an accuracy training stage preceding the rate-building exercises to increase correct see/say rates. The scores of these two children on the phoneme pre-test, their TERA-3 quotients and their scores on the alphabet subtest of the TERA-3 were analyzed, in comparison to the other children in the pre-primary group, to ascertain whether there were any particular skill differences that may have accounted for the variation in results. No differences were found on the measures used.

The very small differences between the pre-primary participants' training rates in the two conditions are worth noting. Most differences between the highest see/say training rates attained in the RB condition compared to in the RBAAT condition ranged from only 3 ppm to 9 ppm for each child, with the exception of one student who had a rate that was 20 ppm higher in the RBAAT condition than in the RB condition. Thus, the instructional procedures in the RB and RBAAT conditions were, for at least six of these younger children, similar in terms of efficiency in building correct see/say phoneme rates.

The baseline one-minute timings indicated that incorrect rates were relatively high for three of the pre-primary children. The error rates were particularly high for those children who made little attempt to read the phonemes, but rather said, “skip” continuously or made other alternative responses. For example, some of the children simply counted over the entire timing. One child sang the alphabet song. Another child said random words and another pretended to read a story. When error rates were higher in one condition than in the other, these findings were likely to be the consequence of the sequence effects that were discussed in relation to the Year 2 participants’ baseline error rates.

The pre-primary children showed continuing decreases in incorrect rates during training in the two conditions over the intervention phase, indicating both sets of procedures were effective in reducing error rates. Elena, Reece and Bryce demonstrated incorrect rates that were comparable in the two conditions after accuracy training in the RBAAT condition. Thus, the instructional procedures in the two conditions were equally effective in reducing the error rates of these three children. The incorrect rates for three of the other pre-primary individuals were higher in the RB condition for a number of timings than in the RBAAT condition, after accuracy training in the latter condition, indicating that the RBAAT training procedure was slightly more efficient in decreasing the see/say phonemes error rates for these three children. The final pre-primary participant, Leon, demonstrated a higher incorrect rate in the RBAAT condition than in the RB condition for one timing after accuracy training in the RBAAT condition. However, his rates in the two conditions were similar for the remainder of the intervention phase, which suggested there was little difference in the efficiency of the RB and RBAAT procedures for decreasing the incorrect see/say phonemes rates for this child. The group mean incorrect rate during training for the pre-primary children was slightly higher in the RB condition by 1.5. The incorrect rates of four of the participants were similar in the two conditions and for the other three incorrect rates were generally lower in the RBAAT condition. Although the difference in the efficiency of the RB and RBAAT procedures for decreasing incorrect see/say phonemes rates was minimal, the RBAAT procedures were marginally superior in decreasing the error rates.

In conclusion, five of the pre-primary children attained higher correct see/say training rates in the RBAAT condition than in the RB condition. Whilst the other two children achieved higher training rates in the RB condition, the differences between the rates in the two conditions were very small. The group mean correct training rate was higher in the RBAAT condition. In addition, four of the participants showed slightly lower or comparable incorrect see/say rates in the RBAAT condition than in the RB condition and the group mean was lower in the former condition. Thus, training accuracy to 100% before rate-building in a two-stage procedure was generally a superior method of training see/say phoneme rates than training accuracy and rate simultaneously. However, there were only minimal differences in training rates for six of the seven children and, therefore, the RBAAT instructional procedure was only marginally superior to the RB training procedure for most of the pre-primary children.

The disparity in results for two individuals within the pre-primary group may have reflected individual differences of the learners. Johnson & Layng (1994) maintain that, in their experience, some learners are able to establish skills and build rate simultaneously, whereas some learners need to build accuracy first and then build rate. They suggest using individual performance rate data and learning rates to determine the form of training that is most beneficial for the individual. According to the present results, the use of individual data in practice seems a more appropriate approach for determining the most advantageous procedure for training see/say phoneme rates than prescribing one method of training for all learners.

Effects on the RESAA outcomes

Year 2 participant RESAA results

Each of the children in the Year 2 group demonstrated 0 ppm correct rates on the retention, endurance, stability, application and Adduction 2 pre-tests in the RB and RBAAT conditions prior to the commencement of the intervention. However, the attainment of low correct rates on the Adduction 1 pre-tests by two children highlighted a possible limitation of this adduction measure in Study 1. The tests assessed adduction across one learning-channel from the see/say task involved in training to the hear/say task involved in the Adduction 1 tests. The participants were required to say the phonemes for each digraph and individual letter in a pseudoword after it was read to them. The sounds of the digraphs and letters were chosen for testing rather than the letter names to remain consistent with the training task and to avoid restrictions being placed on adduction rates by the confounding effects of low accuracy or low rates in saying letter names (a separate component skill). However, the fact that these children attained correct rates, albeit low ones, on the Adduction 1 baseline tests highlighted that the tests may have assessed a skill that was not entirely related to the see/say training task. Rather, the Adduction 1 tests may have actually assessed the level of phonemic awareness of the children through the oral phonemic segmentation task, a task that is often cited as a test of higher-level phonemic awareness (Ball & Blachman, 1988; Juel, 1988; Griffith & Olson, 1992; Yopp, 1992). In these tests the participants did not necessarily need the ability to read the phonemes, but instead were required to be able to "hear" the individual phonemes within the pseudowords and to be able to segment these orally. Thus, these tests actually showed that some children had a higher level of phonemic awareness than others. This limitation in the Study 1 Adduction 1 measures influenced the subsequent design of the Adduction 1 tests in Study 2.

All of the Year 2 children showed increases in rates on each of the RESAA post-tests in both conditions. Thus, the increases in correct see/say training rates affected increases in correct rates on each of the RESAA post-tests. These results lend support to a number of claims in the rate-building literature that improvements in performance rates of a skill lead to greater retention of the skill and improved performance of the skill over longer time periods than those in which it was originally trained (Dougherty & Johnston, 1996; Lindsley, 1996b; Johnson, 1991; Binder 1996; Bolich & Sweeney, 1996). The findings that rates increased on each of the stability measures also supported reports that increases in the performance rates of a skill lead to decreased distractibility (Dougherty & Johnston, 1996; Lindsley, 1992b; Binder, Haughton & Van Eyk, 1990; McDowell & Keenan, 2001). Furthermore, the current results supported the findings reported by other practitioners and in other rate-building research that increases in the performance rates of a component skill lead to increased application of the skill to higher-level composite tasks and to the combination of the skill with other component skills to form novel, untaught behaviours (Johnson & Layng, 1996; 1994a; Binder, 1988; 1996; 1990b; Beck & Clement, 1991; Speece, Mills, Ritchy & Hillman, 2003; Bloom, 1986; Binder & Bloom, 1989).

The group mean correct rates were consistently higher in the RB condition than in the RBAAT condition for each RESAA post-test. Individuals also demonstrated consistently higher rates on a greater proportion of the RESAA post-tests in the RB condition. It was likely that the simultaneous development of accuracy and rate in the RB condition allowed the children to build higher training rates than in the RBAAT condition, within the same time period, and that the higher training rates influenced greater achievement of rates on the RESAA measures.

Pre-primary RESAA results

The pre-primary children also demonstrated 0 ppm correct rates on the retention, endurance, stability, application and Adduction 2 pre-tests in the two conditions. However, six participants attained low correct rates on the Adduction 1 pre-tests in either one or both conditions. These findings were similar to the Year 2 results in so far as the pre-primary children were able to achieve low rates on the Adduction 1 pre-tests even though they were unable to read any of the phonemes. These observations support the suggestion made earlier that the Adduction 1 tests may have assessed a skill not entirely related to the training task and, rather, gave an indication of the participants' pre-existing levels of phonemic awareness.

The pre-primary children demonstrated increases in correct rates on most of the RESAA post-tests. However, two of the children did not demonstrate increases in rates on the Application 2 post-tests in either condition and their rates remained at 0 ppm. Two other participants made only small gains in either the RB or the RBAAT condition from the Application 2 pre-tests to the post-tests. Similarly, Bryce made no rate gains on the Adduction 1 or Adduction 2 post-tests in either condition. Renee also had a rate of 0 ppm on the Adduction 2 post-test for the RBAAT condition. Therefore, although see/say training rate increases influenced improvements in correct rates on most RESAA post-tests for most of the children, they did not guarantee rate gains on all of the RESAA post-tests for all of the children.

One possible explanation for some pre-primary participants' lack of achievement on the RESAA post-tests may have been that their training rates were not sufficiently high to facilitate such gains. The highest rate achieved by any of the participants was 65 ppm in the RB condition and 68 in the RBAAT condition. Although there is little consistency in the literature concerning optimum proficiency rates, many practitioners maintain that fluent performance rates are above 100 per minute (Johnson & Layng, 1994b; Kuhn & Stahl, 2003; Beck & Clement, 1991; Polk & Miller, 1994; Mercer, Mercr & Evans, 1986; Haughton, 1972). Most of the pre-primary children attained rates of around or below 50 ppm in the two conditions, a rate that is generally regarded as low by practitioners (Evans, Mercer & Evans, 1983; Mounsteven, 1990; Lindsley, 1996b). Future research may investigate the effects on each of the RESAA measures of higher see/say phoneme training rates with pre-primary children. It was also observed that Elena achieved the highest training rates in both conditions of all the pre-primary participants. She was also a consistently high performer in relation to the other children on most of the RESAA post-tests, which suggested higher training rates may have facilitated greater achievement of rates on the RESAA measures. Similarly, Martin attained the second highest training rates in each condition and he outperformed most of the other participants on most of the RESAA post-tests also. However, he was not amongst the higher performers on the adduction post-tests.

The group mean correct rates were higher in the RBAAT condition than in the RB condition for all but one of the RESAA post-tests. The group mean for the Application 2 post-test was slightly higher in the RB condition. Individuals also performed at superior rates on a greater proportion of the RESAA post-tests in the RBAAT condition than in the RB condition. Thus, for most of the pre-primary participants, the RBAAT procedures produced slightly higher training rates compared to the RB procedures, and the higher RBAAT training rates produced concurrently higher RESAA rates in the RBAAT condition compared to in the RB condition.

Effects on long-term retention

The effects of training in the RB and RBAAT conditions on the rates on each of the RESAA measures were assessed three months after the termination of the intervention.

Year 2 follow-up results

Significant decreases were observed in correct see/say rates on the training rate retention tests in the RBAAT condition from the post-tests to the follow-up tests for all of the Year 2 children. Four of these children also demonstrated significant decreases in correct see/say rates on the training rate retention measures in the RB condition from the post-test to the follow-up test phase. Christine, however, only showed a slight decrease in correct see/say rate in the RB condition between these phases. The group mean correct rates decreased significantly in both conditions from the post-tests to the follow-up tests, although the group mean was higher in the RB condition by 20.4, and four of the five children attained higher correct see/say rates in the RB condition on the follow-up training rate retention tests. Thus, although the rates that were attained on the short-term training rate retention post-tests were generally not maintained on the long-term retention tests during follow-up, a greater degree of retention was observed in the RB condition compared to in the RBAAT condition. This finding was likely the result of the higher see/say training rates achieved in the RB condition, which produced concurrently higher retention rates three months after the completion of the intervention.

The group mean correct rates for the Year 2 participants were higher in the RB condition for most of the remaining RESAA follow-up tests. Slightly higher group mean correct rates were found only for the stability tests during the follow-up phase. Individuals also performed at rates that were higher on a greater proportion (60%) of the RESAA follow-up tests in the RB condition. The children performed at rates that were higher on the follow-up tests in the RBAAT condition for only 27% of the RESAA measures. The children attained equal rates in the two conditions for 13% of the RESAA tests. Thus, the higher see/say training rates that were achieved in the RB condition compared to in the RBAAT condition during training produced higher rates on most of the RESAA measures in the RB condition than in the RBAAT condition three months after the termination of the intervention.

Pre-primary follow-up results

Interestingly, the group mean correct rates for the pre-primary group were also higher for most of the RESAA follow-up tests in the RB condition. The means for only the retention and the Adduction 2 follow-up tests were higher in the RBAAT condition than in the RB condition. However, individual data showed that more children attained higher rates on a greater proportion of the RESAA follow-up tests in the RBAAT condition (46%) than in the RB condition (37%), although the difference between the two proportions of 9% was very small. These findings were consistent with those during the intervention and post-test phases in which only minimal differences between performance rates in the two conditions were also observed. Thus, it follows that the RB and RBAAT instructional procedures were comparable in terms of efficiency in building see/say training rates over an equal time period and that the similar training rates in the two conditions produced similar rates on the RESAA measures three months after the intervention phase was completed.

The effects of practice and reinforcement

Two common limitations of empirical studies of rate-building have been the lack of control for practice effects and reinforcement effects (Doughty, Chase & O'Shields, 2004). In the current study, the quantities of practice and reinforcement in the two conditions were measured. Thus, it was possible to examine the practice and reinforcement effects in relation to the other results of the study.

The Year 2 children required a far greater number of phoneme repetitions to acquire and maintain accuracy in the RBAAT condition than in the RB condition. However, even though these children were involved in smaller quantities of practice, all achieved higher see/say training rates on the post-tests in the RB condition. In addition, the group mean rates on the post-test RESAA measures were higher in the RB condition and individuals achieved higher rates on a greater proportion of RESAA tests in this condition (86%) compared to in the RBAAT condition (14%). These findings indicated that it was the rate-building procedures in the RB condition and not the quantity of practice that was accountable for the superior performances of these children. These students were also found to have each received a greater quantity of reinforcement in the RBAAT condition than in the RB condition. Thus, the improved performance in the RB condition was not attributable to the quantity of reinforcement either. Even with greater quantities of reinforcement and practice in the RBAAT condition, training accuracy before attempting to build rate was still far less efficient than training accuracy and rate simultaneously for the Year 2 children.

The pre-primary children also required more phoneme repetitions to acquire and maintain accuracy in the RBAAT condition than in the RB condition. In addition, each child also received more reinforcement in the former condition. Two of the pre-primary individuals reached higher training rates in the RB condition. Thus, for these two children the effects of practice and reinforcement were not the factors influencing higher correct training rates in the RB condition but rather the immediate focus on rate-building was more efficient. However, five of the seven pre-primary children attained training rates that were higher in the RBAAT condition. As they also received more reinforcement and practice repetitions in the RBAAT condition, it could not be concluded with certainty that only the instructional methods in this condition were accountable for the superior training rates of these individuals. However, there were only small differences between the see/say training rates in the two conditions for six of the seven pre-primary children. Thus, the greater quantities of practice and reinforcement required in the RBAAT condition to produce only marginally higher training rates as those attained in the RB condition, within the same training period of time, signified a much greater expenditure of effort in the RBAAT condition to facilitate only minimally superior results.

Comparison of Year 2 and pre-primary participant results

The Year 2 children achieved higher see/say training rates and generally higher RESAA rates on the post-tests and follow-up tests in the RB condition. In contrast, the pre-primary children generally demonstrated slightly higher training rates and RESAA rates on the post-tests in the RBAAT conditions and individuals performed at higher rates on a greater proportion of the follow-up tests in the RBAAT condition. An analysis of reading pre-skills may offer explanations for the differences in efficiency between the RB and RBAAT training procedures for the Year 2 and pre-primary groups. Two pre-requisite skills for reading that are commonly cited are phonemic awareness and alphabetic awareness (Felton & Brown, 1990; McBride-Chang, 1996; Speece, Mills, Ritchey & Hillman, 2003; McCormick, Stoner & Duncan, 1994).

The importance of phonemic awareness is based on the argument that speech comprises series of individual sounds and is widely considered an integral element in beginning reading success (Yopp, 1992; Adams, 1990; Juel, 1988; Griffith & Olson, 1992; Carnine, Silbert & Kameenui, 1997; Chall, 1983; Ball & Blachman, 1988; Beck & Juel, 1992; Stanovich, 1994). Thus, phonemic awareness refers to the learner's ability to "hear" the individual sounds within the spoken language. It is often claimed that many children enter Year 1 without phonemic awareness (Yopp, 1992; 1995; Ball & Blachman, 1988). Although phonemic awareness was not specifically assessed before the commencement of the intervention, there were indications than the Year 2 participants had higher levels of phonemic awareness than the pre-primary children. For example, on the TERA-3 over half of the pre-primary children responded incorrectly to the item "What letter does the word *blue* start with?". Similarly, two pre-primary children were unable to respond correctly to the item “point to the picture that starts with the letter *b*”. In contrast, the Year 2 participants were able to accurately match words with pictures and read some letters and words.

Alphabetic awareness describes a learner’s knowledge of the letters of the alphabet and the associated understanding that the alphabet symbolizes the sounds of spoken language (Carnine, Silbert & Kameenui, 1990). The Year 2 children were able to provide the sounds for all of the letters in the alphabet and some of the digraph sounds on the pre-tests administered before the commencement of the intervention (although these digraphs were not included in the sets used during the intervention). Conversely, the pre-primary participants were able to provide very few, if any, of the sounds for the letters in the alphabet. Additionally, some of the items on the TERA-3 highlighted differences in understanding about print. For example, many of the pre-primary individuals were unable to respond accurately to items such as “point to the writing” and “point to the first letter in the word *doll*”, items that were easily achieved by each of the Year 2 participants.

The differences in the efficiencies of the two rate-building procedures in the RB and RBAAT conditions for the Year 2 children in comparison to the pre-primary children can likely be explained in terms of differences in the levels of pre-reading skills, such as phonemic awareness and alphabetic awareness, of these two groups of students. The immediate focus on accuracy <u>and</u> speed may have placed too many performance demands on the pre-primary children, who were likely not equipped with the same level of pre-reading skills as the Year 2 participants. The theoretical concepts of component-composite relations and generativity, that are fundamental to the Generative Instruction model proposed by Johnson & Layng (1992; 1994), are applied to explain these results in Chapter 10 where the discussion relates to the findings of both Studies 1 and 2.

The pre-primary participants were unable to achieve correct training rates that were as high as those attained by the Year 2 participants over an equal period of time. The view that older children are capable of building higher response rates than younger children was reflected in much of the literature relating to norm-referenced procedures for setting rate aims, in which successively higher aims have been recommended for progressively older children (Mercer, Mercer, 1985; Howell & Howell, 1990; Rasinski, Padak, Linek & Sturtevant, 1994; Meyer & Felton, 1999). Mercer, Mercer & Evans (1986) also specifically highlighted age as a factor that may relate to targeted proficiency levels. The current study may validate the claims that older children are able to build higher response rates than younger children provided they have all of the required component skills. On the other hand, it could be possible that the pre-primary children in the present study may have been able to build rates as high as those attained by the Year 2 children if they had more time and more practice. This issue requires further research, as it has implications for practitioners. Perhaps younger children need to be provided with more time and practice to acquire and consolidate a skill than older children. Alternatively, perhaps younger children need more training in the components involved in rate-building that have still to be identified.

Conclusion

Although correct training rates increased in both conditions for the Year 2 and pre-primary children, there were differences in the training rates between conditions. These differences highlighted one set of instructional procedures as more efficient than the other in increasing the training rates of see/say phonemes over an equal period of time for the same children. For the Year 2 participants, the RB training procedures produced higher training rates, with less practice and smaller quantities of reinforcement over the eight-week intervention phase compared to the RBAAT procedures. Thus, the simultaneous training of accuracy and rate was a more effective and efficient means of training see/say phoneme rates than teaching 100% accuracy before building rate.

In contrast, most of the pre-primary participants demonstrated slightly higher correct rates in the RBAAT condition than in the RB condition, indicating the RBAAT procedures were marginally more efficient in building the rates of see-phonemes over the eight-week intervention period. The pre-primary children, therefore, benefited slightly more from a procedure in which accurate phonemes were trained to 100% before attempting to build the rate of see/say phonemes compared to a procedure in which no accuracy training preceded rate-building. Although the pre-primary children's performances were marginally superior in the RBAAT condition, the greater expenditure of effort to attain only minimally superior results, in terms of the requirement for greater quantities of practice and reinforcement in this condition, demonstrated that the RBAAT training procedure was not significantly more efficient than the RB training procedures.

A direct relationship was implied between the training rates and the rates attained on the RESAA post-tests. Both the group and individual data showed that the Year 2 participants demonstrated superior training rates in the RB condition. Likewise, these children performed at higher rates on most of the RESAA post-tests and follow-up tests in the RB condition and the mean was higher for the group in this condition. Similarly, the pre-primary participants demonstrated slightly higher training rates as a group in the

RBAAT condition, and most individuals also attained higher training rates in this condition. The group means were also higher for all but one of the RESAA post-tests in the RBAAT condition for the pre-primary students. The follow-up data showed minimal differences. Overall, these findings suggested that the higher the training rates, the higher the rates on the RESAA measures. Correlational analyses were conducted between each child's highest training rates and their rates on the RESAA post-tests but the results were highly variable and inconclusive and were therefore not included. The small sample may have been responsible for the variation in the correlational analyses.

The higher training rates in a particular condition and the concurrently higher rates on the RESAA measures in that condition lend credence to the premise postulated by other advocates of rate-building procedures that the higher the performance rates of a skill the greater the retention, endurance and stability of the skill (Ivarie, 1986; McDowell & Keenan, 2001; Dougherty & Johnston, 1996; Binder, Haughton & Van Eyk, 1990; Binder 1996), and the greater the application of the skill to higher-level composite skills (Johnson & Layng, 1996; 1994; Koorland, Keel & Ueberhorst, 1990; Haughton 1972; Starlin, 1972). The adduction data also suggested that increases in response rates produce increases in skill adduction, although the rates on the adduction measures were low. Greater adduction appeared to be evident for a one learning-channel cross than for a two learning-channel cross, but the possible limitation of the Adduction 1 measure that was highlighted limited the interpretation of these results.

There were far greater differences between the Year 2 children's performances in the two conditions than there were between the preprimary students' performances in the two conditions. This suggested that there was a greater difference in terms of efficiency between the RB and RBAAT training procedures for the Year 2 children than for the pr-primary children. However, the differences in the two training procedures in terms of efficiency in increasing training and RESAA rates for the pre-primary children were minimal.

Implications for future research

The study has highlighted some implications and directions for future research. A limitation in the present study was highlighted in the Adduction 1 measure. The finding that the see/say phonemes training skill was not required to demonstrate minimal accurate performance on the Adduction 1 pre-tests implied the need to develop an alternative one-channel cross adduction test. In Study 2, the Adduction 1 tests are revised and assess the participants' ability to orally spell the pseudowords using letter names to overcome the limitation in the current study.

A further limitation of the current study was the lack of testing for phonemic awareness, other reading pre-skills and rate-building component skills before the commencement of the study. Thus, although it was possible to speculate that the pre-primary children were more deficient in these skills than the Year 2 children, because the TERA-3 and pre-test data implied this was the case, it was not possible to form conclusions concerning the level of other pre-skills of the children with absolute certainty. Future studies may replicate the current research and include a wider range of reading pre-skills tests and rate-building component skills, such as rapid speech training (e.g., rapid colour naming) prior to the commencement of the intervention.

The effects of training to only a 100% accuracy criterion were investigated in the present research project. Other researchers have suggested different levels of optimum accuracy before beginning rate-building exercises. For example, Howell & Howell (1990) asserted that learners have to attain an accuracy criterion of 85% before rate-building. The pre-primary children in this study may have gained as much benefit from only training to 50% accuracy, for example, as from training to 100% accuracy before attempting to build rate. Thus, future research should examine the effects of training the participants to different accuracy criteria before beginning rate-building exercises. The sensitivity of the rate of response measures in comparison to percentage correct measures that was explicitly highlighted in this study implies that it is imperative for future research of this kind to include measures of freely-emitted responses after an accuracy training stage. All of the children achieved the 100% accuracy criterion on two consecutive trials before rate building commenced in the RBAAT condition. However, the see/say rate probes that were conducted immediately after the accuracy training stage, and throughout the rate-building stage, clearly indicated different levels of competency of see/say phonemes for one phoneme set compared to the other set for individual participants. The rate measures also revealed different levels of competency of see/say phonemes between the pre-primary and Year 2 children beyond the 100% correct criterion.

Future studies may replicate the current study with larger samples to ascertain whether the findings are consistent. Alternatively, other studies may replicate the present research but investigate other academic skills or may involve participants of different age groups with more specific delineation of components for all aspects of the task and skill demands during training.

CHAPTER 7

STUDY 2

An investigation of the effects of the attainment of increased see/say phoneme rates on the RESAA measures at incremental rate aims with children across three levels of reading ability

CHAPTER 7

METHOD

Design

Study 2 comprised a within-subjects design. The participants trained under two experimental conditions and a different set of phonemes was used in each condition. The children were assigned to randomly begin training in one condition and the sets of phonemes were randomly assigned for use during training in each condition.

There were three phases involved in Study 2. Phase A was a baseline phase during which the initial see/say phoneme tests on both sets were assessed. The endurance, visual stability (VS), auditory stability (AS), combined auditory and stability (CAVS), Application 1, Application 2, Adduction 1 and Adduction 2 pre-tests were also conducted in this baseline phase. Phase A extended over a duration of one week.

Phase B followed the baseline phase and comprised the intervention period and repeated measures on the RESAA probes. This phase continued over eight weeks. The treatment was provided for four consecutive days per week over the intervention period. The participants trained in the rate-building (RB) and constrained-rate repeated practice (CRP) conditions in alternate weeks. Repeated measures of free-rate see/say phoneme responses were conducted on see/say training rate probes and on RESAA probes throughout the intervention phase. In the RB condition, these probes were administered immediately following the attainment of a specified rate aim. In the CRP condition, the set of probes was conducted when the children had engaged in the same number of slow-paced phoneme practice repetitions as were required by each child to achieve a particular rate aim in the RB condition.

FIGURE 7.1 : DESIGN FOR STUDY 2

The final Phase C involved follow-up testing three months after the termination of the intervention and was conducted over one week. The sequence of phases for Study 2 therefore followed an A-B-C format and is shown in Figure 7.1. There was no specific post-test phase, as in Study 1, because each of the see/say training rate and RESAA probes comprised measures that were conducted under baseline conditions. Thus, the final probes that were conducted immediately after the intervention was completed were end of intervention measures without a break of sequential testing.

Participants

From the pool of 31 children in Year 2 that were not chosen to participate in Study 1, four individuals who scored within the very poor range on the TERA-3 (quotients of between 35 and 69) and four who scored within the poor range on the TERA-3 (quotients between 70 and 79) were selected. These eight children also scored within the low average to average ranges for verbal IQ on the WISC-III (IQ of between 80 and 109) and had scores of lower than 50% on the digraph pre-test. The digraph pre-test involved testing on the same phoneme list as used in Study 1 to test the Year 2 participants (see Appendix 2). The four children in each group were chosen because their scores on the TERA-3 were most closely related to one another. A pool of 10 children who were described as average readers by their teachers were then tested on the TERA-3, WISC-III and on the digraph list. From this pool of children four were chosen to participate. These individuals scored within the average ranges on the TERA-3 (quotients of between 90 and 110) and for the verbal IQ of the WISC-III (IQ between 80 and 109), and had low scores on the digraph pre-test. All of the participants involved in Study 2 were also tested on their knowledge of the letter names

Table 7.1: Age, WISC-III verbal IQ and TERA-3 reading quotients for the participants in Study 2.

Participants	**Age**	**WISC-III (verbal IQ)**	**TERA (reading quotient)**
Average range on the TERA			
Lucy	7:1	104	94
Tahni	6:11	102	94
Lee	7:3	106	94
Kyle	6:8	104	100
Means	7 (SD = 0.22 years)	104 (SD = 1.41)	95.5 (SD = 2.59)
Poor range on the TERA			
Troy	6:10	102	74
Liam	7:2	93	74
Ryan	7:1	92	74
Wesley	7:7	97	74
Means	7:2 (SD = 0.27 years)	96 (SD = 3.94)	74 (SD = 0)
Very poor range on the TERA			
Christopher	8:1	89	64
Aaron	7:1	91	66
Sean	7:3	89	61
James	7:1	84	64
Means	7:4 (SD = 0.41 years)	88.25 (SD = 2.59)	63.75 (SD = 1.79)

for “m” and “a”. Each of the participants was able to say these letter names accurately on three consecutive trials without hesitation.

The majority of the twelve participants in Study 2 ranged in age from six years and eight months to seven years and seven months. One child had repeated pre-primary earlier in his education and was therefore slightly older than the other children in the study. He was aged eight years and one month. The scores on each of the tests and the ages of the individual participants are shown in Table 7.1.

Materials

The two learning sets containing six digraphs that were used for the Year 2 participants in Study 1 were also utilized in Study 2. These digraphs are listed in Appendix 3. On the digraph pre-test each of the children responded incorrectly to each of these digraphs. The same laminated cards displaying these phonemes that were used in Study 1 were also used in Study 2 and again there were two examples of each phonemes included in the sets to make twelve cards in each. For each individual in Study 2, one of the sets was randomly assigned for use in the RB condition whilst the other set was used in the CRP condition.

The pseudoword sets that were used for the Application 1 and 2 tests and the Adduction 1 tests in Study 1 were again used in Study 2 for the same tests. Each set contained six different pseudowords and there were two examples of each word to make twelve pseudowords in each set. The pseudowords are listed in Appendix 4.

The Adduction 2 tests involved the use of worksheets on which the participants used pencils to circle the appropriate phonemes in the correct order to spell the pseudowords. The worksheets that were created for Study 1 were also used in Study 2. Examples of these worksheets are shown in Appendix 5.

An electronic timer was used to measure intervals of timed repeated practice during the intervention and to time the presentation of a new phoneme every three seconds during constrained-rate practice in the CRP condition. The timer allowed a specific number of seconds and minutes to be entered. It counted down the specific number of seconds and emitted an electronic sound when a particular interval was completed.

The reinforcement system that was described in Study 1 was also used in Study 2. The participants were provided with charts containing five grids (see Appendix 6). Each grid comprised 10 empty squares. Tokens in the form of stickers were awarded and placed in the squares on each grid when responses were reinforced. When the participants had received enough stickers to complete a grid they were allowed to choose an article from the treasure box that contained small toys and edible items. Completion of the whole chart, or all five grids, resulted in the awarding of a certificate that the children were allowed to take home to show their parents along with the completed chart.

Independent variables

Two independent variables in Study 2 were the types of repeated practice of see/say phonemes. In the RB condition the participants were involved in timed repeated practice in which reinforcement was contingent on building accuracy and speed. In the CRP condition the children were involved in constrained-rate repeated practice in which accuracy alone was reinforced and the pace of stimulus presentation made it impossible for the participants to build the speed of see/say phonemes beyond 20 ppm. The number of practice repetitions of the phonemes was carefully controlled in the CRP condition. The participants each received the same number of phoneme practice repetitions in the CRP condition as were required to attain each rate aim in the RB condition.

The specified rate aims for the RB condition and the number of practice repetitions in the RBAAT condition constituted other independent variables. The children were involved in rate-building exercises in the RB condition until they attained specific rate aims. When each rate aim was achieved on a one-minute timing during practice, the effects of the attainment of that particular response rate on the set of RESAA measures were probed. In the CRP condition, the children were involved in slow-paced repeated practice of the phonemes until they had completed the same quantity of phoneme repetitions as were required in the RB condition to reach a particular rate aim. The see/say rate probes and the set of RESAA probes were then conducted after each specified number of practice repetitions were completed.

Dependent variables

The correct and incorrect see/say phonemes rates comprised dependent variables during training and as performance measures in the retention, endurance, stability and application probes. Correct rates were defined as the number of correct responses per minute and incorrect rates were the number of incorrect responses per minute. Both were expressed as the number of phonemes per minute (ppm). A correct response was recorded each time a participant read a digraph accurately which involved saying one sound for each digraph. An incorrect response was noted on each occasion that the children read the individual letters in a digraph, read the digraph inaccurately, omitted a digraph or indicated that they were unable to read the digraph.

The hear/say phoneme rates and hear/mark phoneme rates on the Adduction 1 and Adduction 2 tests constituted other dependent variables. A correct hear/say response was defined as each correct letter name given for a digraph in the appropriate order. For example, after hearing the word “amai”, the children were required to say the letter names “A”, “M”, “A”, “I” in that order. A correct response was scored when the target digraph was spelled correctly using the letter names and in the correct order of the word. An incorrect hear/say response was noted when participants said letter sounds instead of letter names, gave incorrect letter names, omitted letters or indicated that they were unable to spell the word. A correct hear/mark (circle) response was defined as each correct digraph that was circled in the appropriate order on the worksheets. An incorrect hear/mark response was recorded when participants circled an incorrect digraph, circled a digraph in the incorrect order, did not circle a digraph or indicated that they were unable to perform the task.

Measures and scoring of the dependent variables

See/say phoneme rates were measured on the one-minute timings in the RB condition and on the free-rate see/say probes in the CRP condition. See/say phoneme rates were also measured on the retention, endurance, stability and application pre-tests, probes and follow-up tests in both conditions. Scoring of the see/say phoneme rates for the see/say rate probes, retention, endurance and stability measures involved one point being noted for each correct phoneme response. One point was also recorded for each incorrect phoneme response.

The Application 1 and Application 2 tests involved the scoring method used in Study 1. One point was awarded for each correct and for each incorrect see/say response. These rates were then doubled to control for the time taken to see/say the “a” and “m” constants in each word.

Hear/say rates were measured on the Adduction 1 baseline tests, intervention probes and follow-up tests. The participants were required to orally spell the pseudowords using letter names. Again the target phonemes were the digraphs and the constant phonemes ("a" and "m") served only to allow the formation of phonetically regular pseudowords. One point was noted for each correct letter name given for the digraphs in the appropriate order. Thus, there was a maximum of two points awarded for each word as each digraph consisted of two letters. One point was also noted for each incorrect letter in the digraphs.

Hear/mark rates were the measure on the Adduction 2 baseline tests, intervention probes and follow-up tests. As in Study 1, the participants were awarded one point for each correct digraph that was circled in the appropriate order and these rates were then doubled to control for the time taken to circle the "a" and the "m" constant phonemes.

Procedure

Written consent was obtained from the principals in each of the schools and from the parents of the children before the commencement of the study. Each of the children also gave oral consent before beginning baseline testing.

The testing and treatment procedures were conducted in rooms that were separate from the classrooms but within the schools. The children were tested and involved in treatment procedures individually. They sat at a desk and the researcher sat adjacent to them. The numbers of correct and incorrect responses were recorded during each of the timings.

Phase A: Baseline Phase

Each child was randomly assigned to begin baseline testing in either the RB or the CRP condition. A set of phonemes was randomly allocated for that condition. Baseline testing then commenced in that condition for each child. When the children completed the baseline tests in one condition they were immediately involved in baseline testing in the other condition. Reinforcement was contingent on active participation during this phase.

The initial see/say phonemes tests were conducted during this phase for both phoneme sets. The formats of the see/say tests were the same as those described for the Year 2 participants in Study 1. That is, a demonstration was given to the children indicating how to say one sound for each digraph. Two examples were shown that were different digraphs from those included in either the RB or CRP sets. The appropriate set of phoneme cards was then placed on the children's desks in a circular arrangement. They were told to begin at a randomly chosen phoneme and to continue reading the phonemes as quickly as possible around the circle until the timer sounded. They were instructed to say, "skip" for any phonemes that they were unable to read. The timer was set for a one-minute interval and the children began reading at the same moment as the timer was started.

The endurance, VS, AS, CAVS, Application 1, Application 2, Adduction 1, and Adduction 2 tests were then conducted in random order. Again the formats of these tests were the same as were described for the Year 2 participants in Study 1. The endurance tests were conducted over three minutes. Each of the stability tests consisted of one-minute timings. The VS tests were conducted as the child's movie (The Jungle Book) was played without sound. The movie sound-track was played without the picture during the AS tests, and the picture and the sound were played as the CAVS tests were administered.

The pseudowords were used for the Application 1 and Application 2 tests and these assessments also followed the same methods as those conducted in Study 1. The children were given two examples that were not included in the RB and CRP sets for each type of test. The Application 1 tests required the participants to orally segment the pseudowords into the digraph and two single phonemes that constituted each word. In the Application 2 tests the children orally blended the phonemes to say the whole words. The pseudowords were placed on the desks in a circular arrangement and the participants were again instructed to continue reading as quickly as possible until the timer sounded. They were told to say, “skip” for any phonemes or words they were unable to read.

The Adduction 1 and Adduction 2 tests involved the use of the pseudowords. The Adduction 1 tests differed slightly from the tests described in Study 1, in which the participants heard a pseudoword and were required to orally segment the word into the digraph and two phonemes that constituted the word using letter and digraph sounds. In Study 2 the task was made more difficult and the participants were required to orally spell the word using letter names for the digraphs and the two separate phonemes. This modification to the Adduction 1 tests was aimed to overcome the limitation of the Adduction 1 tests in Study 1 for which some of the children were able to demonstrate low performance rates even though they were unable to see/say the target phonemes. The Adduction 1 tests in Study 2 otherwise followed the same format as in Study 1. The Adduction 2 tests were identical to those described in Study 1 and involved the participants circling the appropriate digraph and two individual phonemes in the correct order on worksheets to spell the pseudowords after hearing them read by the researcher.

Phase B: Intervention and probes

Phase B followed a teach-test format. Specific target rate aims were created before the commencement of the intervention. The target aims were expressed as successive ranges of 20 ppm. For example, the first target rate aim in the intervention phase was expressed as “21-41 ppm”. The next target rate aim was expressed as “42-62 ppm”, the next “63-83 ppm” and so on. The participants were trained in the RB condition until they attained each target rate aim on a one-minute timing at which point the intervention was suspended and the RESAA probes were conducted. The intervention resumed immediately after the RESAA probes were completed.

In the CRP condition, the participants were involved in the same number of phoneme practice repetitions as were required in the RB condition to attain a particular rate aim. The intervention was also suspended in the CRP condition, following the completion of the specified number of phoneme practice repetitions, and a free-rate see/say phoneme test was administered over one-minute followed by the RESAA probes. The intervention then resumed. The intervention procedure is shown in Figure 7.2.

Procedure in the RB condition.

The procedure for building rate in the RB condition in Study 2 was the identical to the one employed in the RB condition in Study 1. First, the DI procedure (page 116) was used to initially introduce two phonemes in the set. The rate-building exercise sequence followed. This sequence was shown for Study 1 in Figure 4.2 (page 119) and the same series of timed sprints and drills were involved for Study 2.

FIGURE 7.2: SEQUENCE OF PROCEDURE IN STDUY 2

The phoneme cards were again placed in the circular arrangement on the children's desks. They were instructed to read as many of the phonemes as were possible within the time period and to say, "skip" for any phonemes that they were unable to read.

The participants were informed of the length of the timing and the rate aim before each timing commenced. The rate aims were adjusted in the same way as in Study 1 when timings were shorter than one minute in duration. Reinforcement was contingent upon attaining the rate aim for a particular timing. However participants only achieved the target rate aim when they performed the target see/say rate on the one-minute timing in the rate-building sequence. For example, to achieve the 21-41 ppm rate aim the participants had to perform at a rate within this range on the one-minute timing even though they might have attained equivalent rates on the shorter timings.

As in the Study 1 rate-building exercise sequence (page 119), a new phoneme was introduced through the DI procedure each time the exercise sequence was completed, before the commencement of the sequence again. The error correction procedure used in the Study 1 rate-building exercises (page 121) was then used to maintain accuracy as the participants built higher rates.

Procedure in the CRP condition.

In the CRP condition, the participants were initially introduced to two phonemes through the same DI procedure as in the RB condition (page 116). These phonemes were then placed in the set with the untaught phonemes. The children were told that they would be shown the entire set of phonemes and that they were to read any phonemes they could and to say "skip" for those they were unable to read. This procedure replicated the RB procedure in which the participants responded to each phoneme in the circle, saying those they were able to read (or those that had been introduced) and saying, “skip”, for those they were unable to read (or those that had not yet been introduced). Thus, the only difference between the CRP procedure and the RB procedure was the pace at which the participants were able to see/say phonemes. Constrained-rate repeated practice involved the researcher showing one phoneme to the participants every three seconds. Thus, it was impossible for the participants to build rates above 20 ppm.

A new phoneme was introduced in the CRP condition at the same point in the teaching sequence as a new phoneme was taught in the RB condition. That is, the number of phoneme repetitions that were completed in the RB condition before learning a new phoneme was calculated, and the participants received the same number of phoneme repetitions in the CRP before a new phoneme was introduced. Teaching continued in this way until all of the phonemes in the set had been introduced.

The error correction procedure used in the RB condition was also employed in the CRP condition to maintain accuracy. Errors were corrected on each occasion that the participants completed a set of trials.

Reinforcement was contingent upon building higher levels of accuracy. The participants had to increase their accuracy score from the previous set of trials. For example, if a child read two phonemes of the twelve accurately on one set of trials, then he would have to read three or more accurately on the next set of trials. When the participants were able to read all 12 phonemes with 100% accuracy, they were required to read the whole set twice and maintain 100% accuracy. If the participants attained 100% accuracy for the entire set on two consecutive trials, then they were required to read the entire set on three consecutive trials with 100% accuracy. This reinforcement schedule continued so that reinforcement was gradually thinned to avoid reinforcement saturation. When the participants could read the entire set of phonemes on five consecutive trials with 100% accuracy, maintenance of this level of accuracy was reinforced.

The see/say phoneme tests and the RESAA probes were conducted in the CRP condition when the number of phoneme repetitions completed was equal to the number of repetitions that were required in the RB condition to attain a particular rate aim. For example, when a child attained a rate of 31 ppm on the one-minute timing in the RB condition, he achieved the target rate aim of 21-41 ppm. If the number of phoneme repetitions that were completed in the RB condition to attain this rate was 146, this child was then involved in 146 phoneme repetitions in the CRP condition. When 146 phoneme repetitions were completed, the intervention was suspended and the see/say phonemes test and the RESAA probes were assessed in the CRP condition.

A technique was employed to match the number of phoneme repetitions in the two conditions when participants were assigned to begin training in the CRP condition. When this condition preceded participation in the RB condition, it was impossible to know the number of phoneme repetitions that would be necessary to reach a particular rate aim. Therefore, an estimate was made of the number of repetitions that would be necessary to reach a particular target rate aim in the RB condition. These participants then received that number of repetitions in the CRP condition. Any additional phoneme repetitions that were then required during the rate-building exercises in the RB condition were “topped up” in the CRP condition to make the number of repetitions in the two conditions equal.

Phase C: Follow-up

Three months after the intervention was completed, each of the participants was involved in follow-up testing on all of the RESAA outcomes. The RESAA tests administered during the follow-up phase were identical to the tests that were conducted at baseline and to the probes during the intervention phase.

Inter-observer reliability

Inter-observer reliability was assessed during the baseline, intervention and follow-up phases. The twelve children were randomly assigned to one of three groups so that there were four individuals in each group. These groups were then assigned to one of the experimental phases. The children in each group were videotaped according to the experimental phase to which they had been allocated. A second, trained observer then scored the correct responses on each timing from the videotapes.

The children allocated to Group 1 were videotaped whilst they participated in each of the baseline RESAA tests for the RB and CRP conditions. Group 2 children were videotaped for a session for both the RB and CRP conditions during the intervention phase and during the RESAA probes at specific rate aims. Reliability scores are reported for the one-minute timings and each RESAA probe at the 42-62 ppm and 84-104 ppm rate aims for the RB condition and for the corresponding one-minute timings in the CRP condition. Group 3 children were videotaped during the RESAA follow-up tests for the RB and CRP conditions.

The inter-observer reliability scores are shown in Table 7.2. Percentage agreement was calculated by dividing agreement by agreement plus disagreement and multiplying by 100. The means of the percentage agreements were calculated for each rate measure and

Table 7.2: Reliability scores for see/say rate timings and RESAA tests in each experimental phase.

Rate Measures	Reliability (% agreement)					
	Baseline Phase		Intervention Phase		Follow-up Phase	
	RB	CRP	RB	CRP	RB	CRP
One-minute see/say rate	96.4	93.8	92.7	91.8	N/A	N/A
Retention	N/A	N/A	91.2	91.1	94.0	94.4
Endurance	95.3	96.4	90.0	90.2	92.6	91.6
V. Stability	95.8	93.6	94.4	90.7	93.1	94.6
A. Stability	98.5	96.4	90.7	92.2	96.3	93.3
Combined Stability	97.1	93.8	91.5	93.5	95.2	93.3
Application 1	100	100	88.8	92.2	93.9	93.2
Application 2	100	100	90.8	97.4	94.2	97.1
Adduction 1	100	100	100	96.9	95.2	94.4
Adduction 2	95.0	96.9	93.4	100	97.0	100

for each phase. These are shown in Table 7.2. The reliability scores ranged from 88.8% to 100%.

CHAPTER 8

RESULTS OF STUDY (2)

In this chapter, the correct and incorrect see/say rates attained by the participants during intervention training in the RB and CRP conditions will first be presented and comparisons will be made between the two conditions. These data will be described consecutively for the readers scoring within the very poor range on the TERA-3, then for those scoring within the poor range on the TERA-3, followed by the children who scored within the average range on this reading test. Following will be a description of the data relating to each of the RESAA probes for each child and comparisons will again be drawn between conditions. These data will also be presented for the very poor, poor and average readers successively. Comparisons will be drawn between the children's correct see/say rates during training and their rates on each of the RESAA probes in the RB condition. In a following section the data for the three reading ability groups for each of the rate measures will be compared at each rate aim. The chapter will conclude with a summary of the findings of Study 2. As in the results chapter for Study 1, most of the data have been summarized and individual data have been included in the appendices. The appropriate appendices will be referred to throughout this chapter as they relate to the findings that are described.

See/say training rates at each rate aim

The figures referred to in this section show only the rates for the one-minute timings on which individuals achieved each of the rate aims in the RB condition and when they had completed the required number of phoneme repetitions in the CRP condition for a particular rate aim. Participant rates that were assessed on other timings during the rate-building procedure are not included in these figures as the focus of the study was the comparison of rates achieved in the two conditions at the specific rate aims. The phases in each of these figures are labeled. Phase A is the baseline phase, Phase B is the intervention phase and Phase C is the follow-up phase.

See/say training rates for the participants scoring within the very poor reading range on the TERA-3

Figures 8.1 to 8.4 display the one-minute timings on which each target training rate was attained in the RB condition by the four participants scoring within the very poor range on the TERA-3. The figures also show the corresponding free-rate timings conducted in the CRP condition after the children had engaged in the same number of constrained practice repetitions as were required in the RB condition to achieve each rate aim.

Baseline correct see/say rates were very low for each of the participants, ranging from 0 ppm to 2 ppm in the RB condition and from 0 ppm to 3 ppm in the CRP condition. Increases in correct see/say rates were evident in both the RB condition and the CRP conditions during the period of intervention. By the first rate aim in the intervention phase (21-41 ppm) three of the four participants demonstrated higher correct see/say rates in the RB condition than in the CRP condition after receiving an equal number of practice repetitions in both conditions. By the second rate aim, all participants achieved higher correct see/say rates in the RB condition and maintained higher rates than in the CRP condition for the remainder of the intervention period.

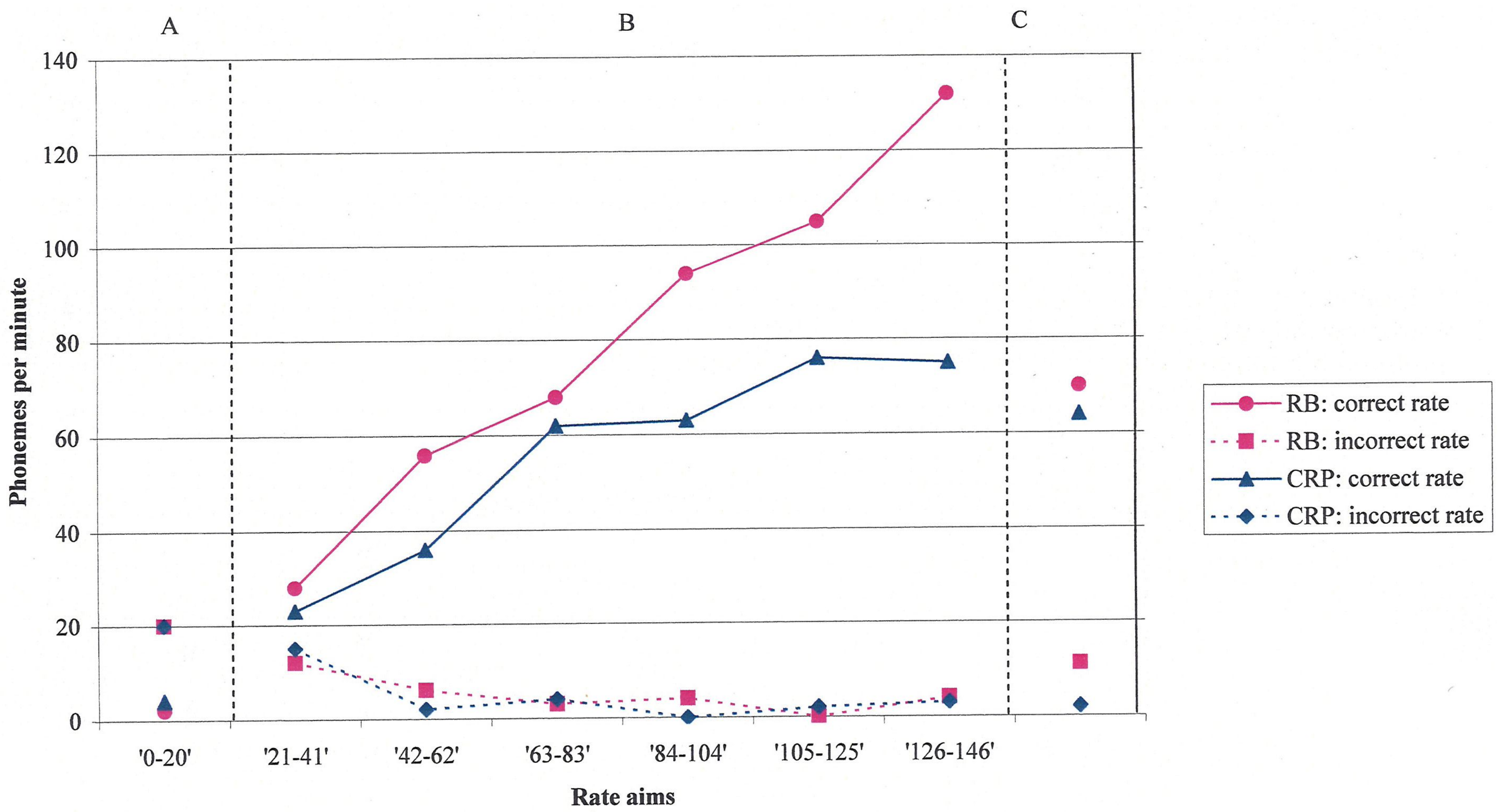

Figure 8.1: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for Aaron

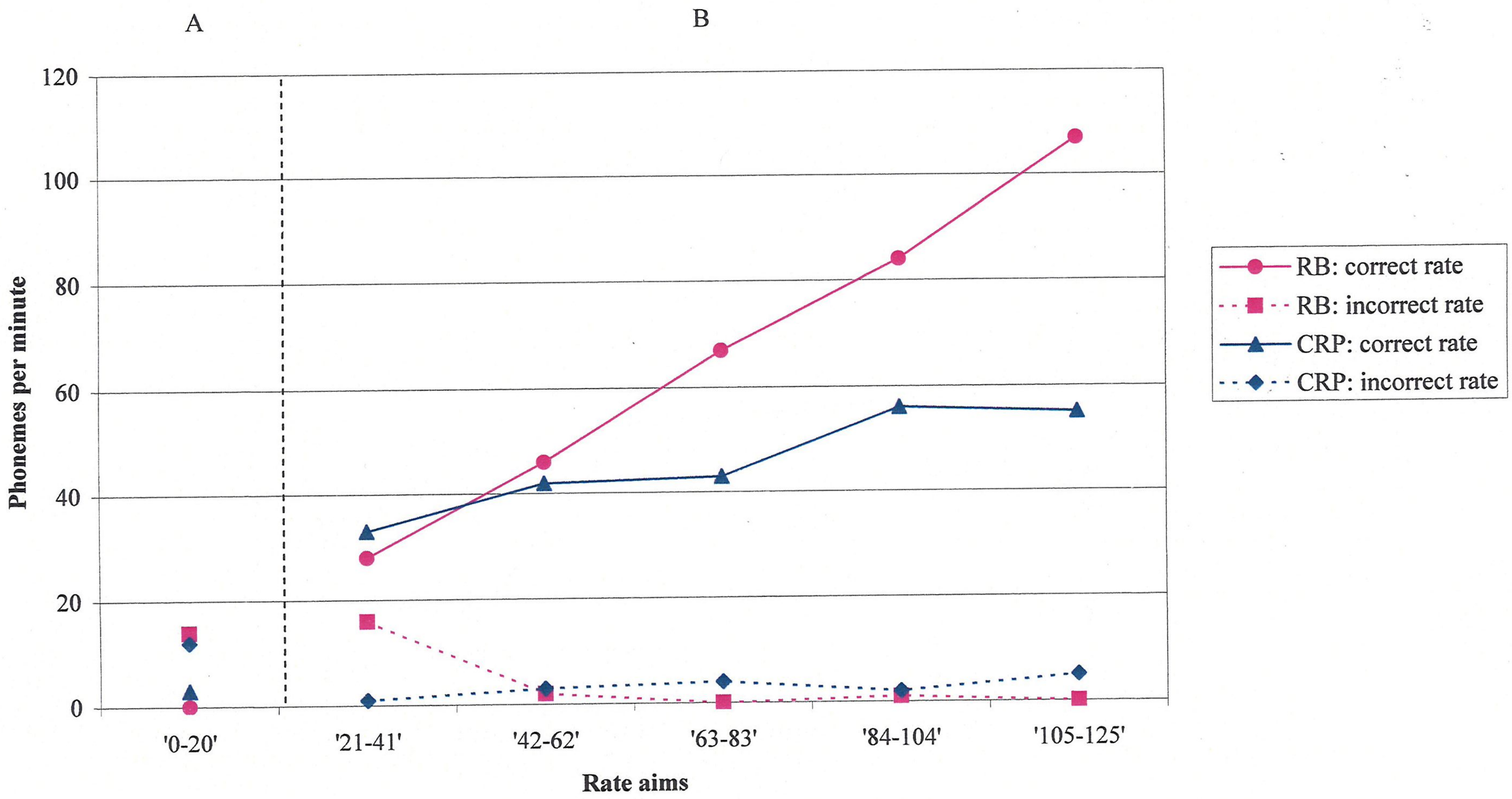

Figure 8.2: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for Christopher

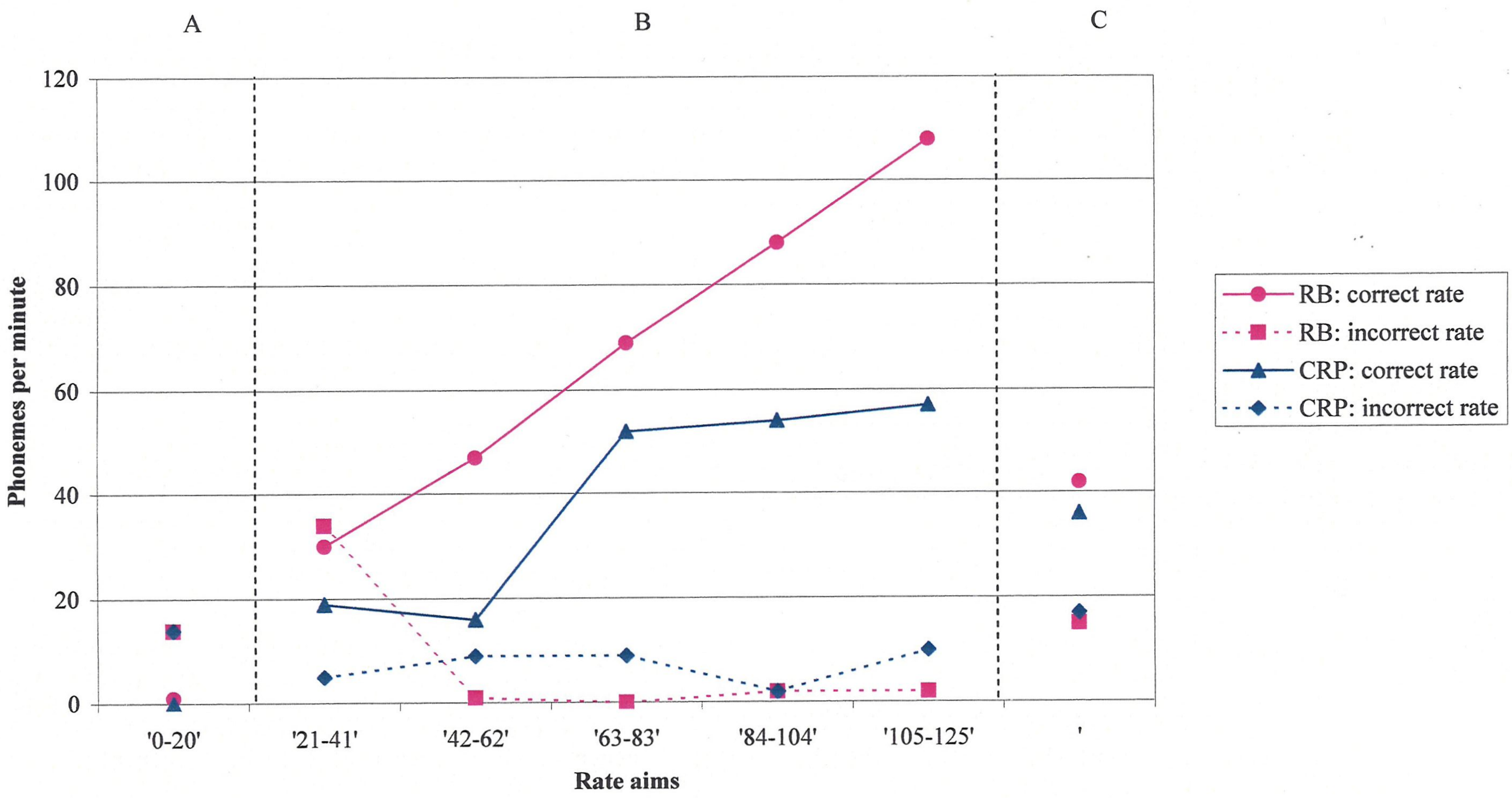

Figure 8.3: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for James

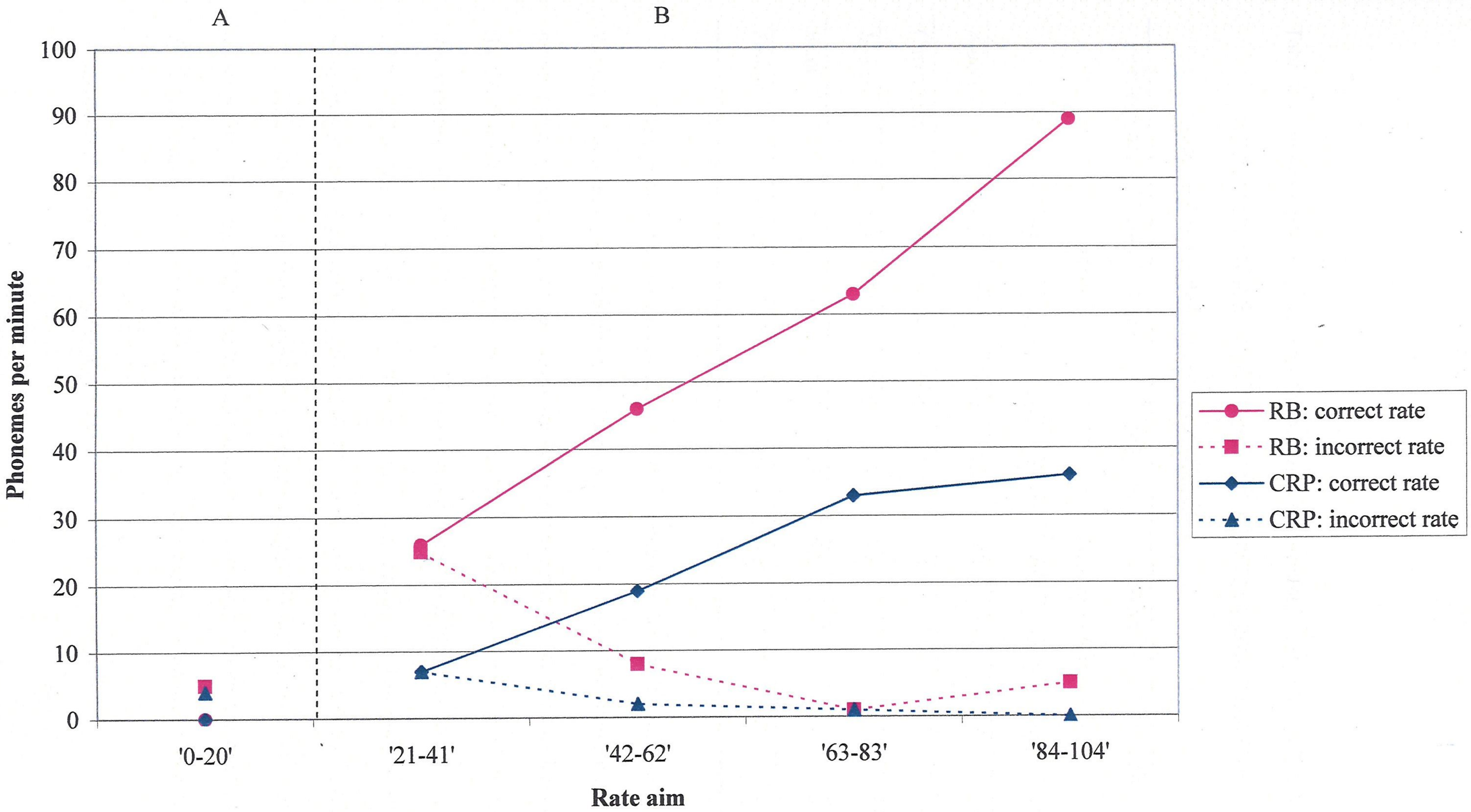

Figure 8.4: Correct and incorrect rates on the one-minute timings in the RB and CRP conditions for Sean

Table 8.1: Mean correct and incorrect see/say rates and standard deviations during the intervention period for the RB and CRP conditions for the participants scoring within the very poor range on the TERA-3.

Participants	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Aaron	80.5	55.8	34.0	19.7	4.8	4.3	3.7	4.9
Christopher	66.4	45.8	27.8	8.7	3.8	3.0	6.1	1.4
James	68.4	39.6	27.9	18.1	7.8	7.0	13.1	3.0
Sean	56	23.8	23.1	11.6	9.8	2.5	9.1	2.7
Group	67.8*	41.3*	8.7	11.6	6.6*	2.4*	4.2	1.7

The mean correct see/say rates and standard deviations during the treatment period for each of the participants are shown in Table 8.1. All four participants attained much higher mean correct see/say rates during the intervention period in the RB condition than in the CRP condition. The group mean correct see/say rate for the intervention phase for the RB condition was 67.8 (SD = 8.7), which was much higher than the group mean rate for the CRP condition of 41.3 (SD = 11.6). The Wilcoxon matched-pairs signed-ranks test revealed a statistically significant difference ($T = 0$, $p < 0.05$) between the two conditions.

Incorrect see/say rates ranged from 5 ppm to 20 ppm in the RB condition and from 4 ppm to 20 ppm in the CRP condition on the baseline measures. There was a general declining trend in incorrect see/say rate data across the intervention period in both

* statistically significant difference ($T = 0$, $p < 0.05$).

conditions for each of the participants. However, the timing for the first intervention rate aim of 21-41 ppm in the RB condition indicated that for three of the participants' incorrect see/say rates actually increased from the baseline phase as the participants initially began to build speed. This trend was not reciprocated in the CRP condition in which most participants showed an immediate decrease in incorrect see/say rates. Nevertheless, incorrect see/say rates in the RB condition declined to levels that were similar to or below those observed in the CRP condition on the timings for the subsequent rate aims.

The mean incorrect see/say rates and standard deviations for each participant during the period of intervention are also shown in Table 8.1. All four participants had slightly lower incorrect see/say rates in the CRP condition than in the RB condition although the differences between the means in the two conditions were very small for three participants, ranging from 0.5 to 0.8. Sean demonstrated a greater difference between the two conditions in incorrect see/say rates of 7.3. The group mean incorrect see/say rate for the intervention period for the CRP condition was 4.2 ($\underline{SD}$ = 1.7) compared to a slightly higher group mean incorrect see/say rate of 6.6 ($\underline{SD}$ = 2.4) in the RB condition. A significant difference was found between conditions on the Wilcoxon test ($T = 0$, $p < 0,05$).

The follow-up see/say rate data are shown in the final phase of Figures 8.1 to 8.4. Only two of the original four participants who scored within the very poor range on the TERA-3 were available for follow-up testing. Although the data indicated a decrease from the intervention phase, both Aaron and James had higher correct rates in the RB condition than in the CRP condition three months after the intervention was completed. The mean of Aaron and James' correct see/say rates on the follow-up tests was 56 ($\underline{SD}$ = 14) in the RB condition and for the CRP condition the mean was 50 ($\underline{SD}$ = 14). The incorrect rates on the follow-up tests had increased for both participants from the intervention phase. The group mean incorrect see/say rates in the two conditions were 13 (SD = 2) and 9.5 (SD = 7.5) for the RB and CRP conditions respectively.

See/say training rates for the participants scoring within the poor range on the TERA-3

Figures 8.5 to 8.8 show the one-minute timings on which each of the rate aims were achieved in the RB condition by the four participants scoring within the poor range on the TERA-3. Their rates on the corresponding one-minute timings in the CRP condition are also shown in these figures.

Baseline correct see/say rates were very low for all four participants, ranging from 0 ppm to 5 ppm in the RB condition and from 0 ppm to 4 ppm in the CRP condition. Each of the participants showed increases in correct see/say rates in both conditions during the intervention period. By the first intervention rate aim (21-41 ppm), two of the participants achieved higher correct see/say rates in the RB condition than in the CRP condition. For the remaining two participants the reverse was observed. Wesley, Ryan and Troy then demonstrated slightly higher correct see/say rates in the CRP condition than in the RB condition for a number of timings. However, their RB rates exceeded their CRP rates after the 105-125 ppm rate aim for Wesley and Troy and after the 63-83 ppm rate aim for Ryan and continued to be higher for the remainder of the intervention period. Alternatively, Liam maintained a higher correct see/say rate in the RB condition than in the CRP condition on the timings for all but one of the rate aims in the intervention period.

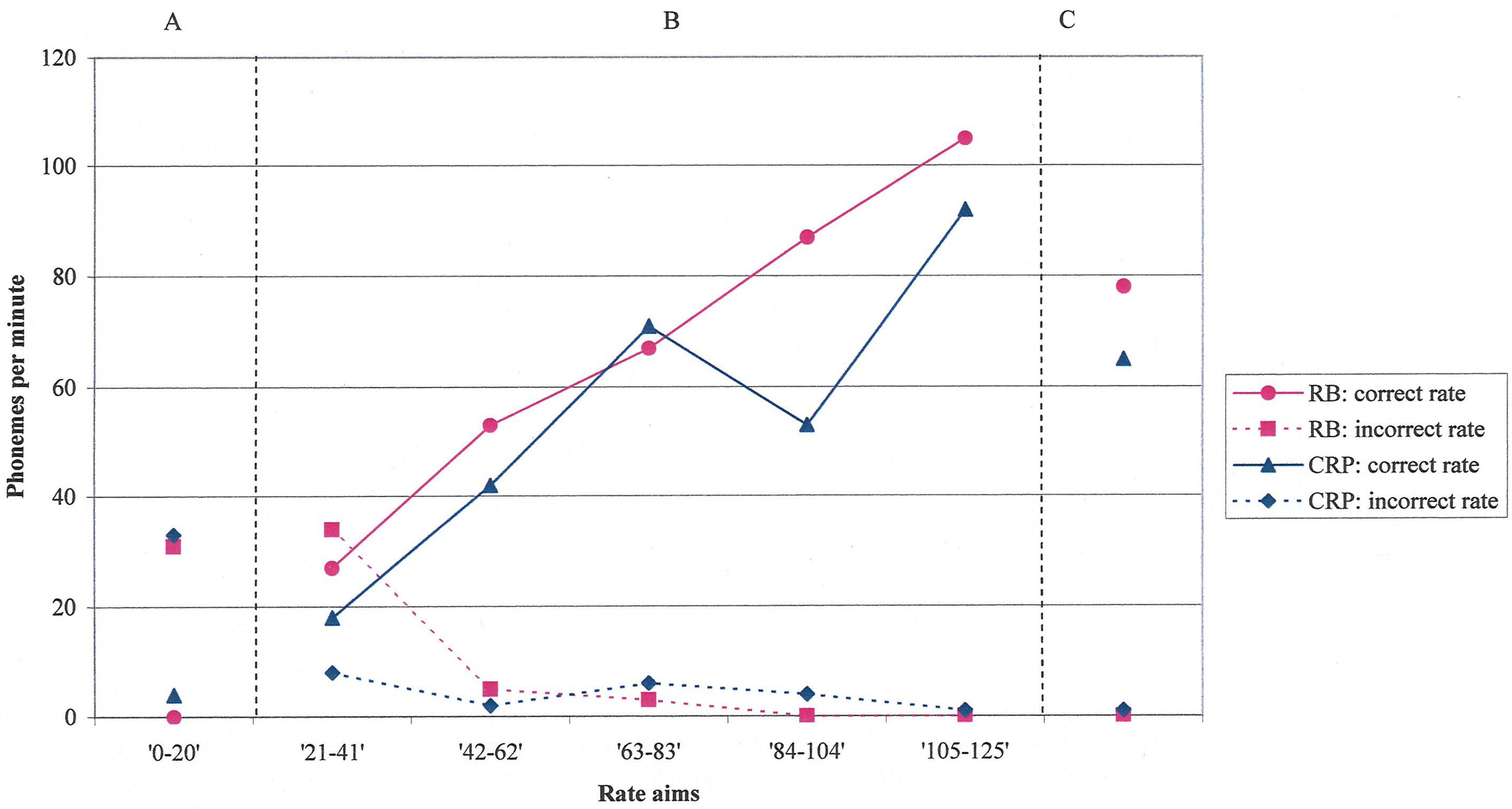

Figure 8.5: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for Liam

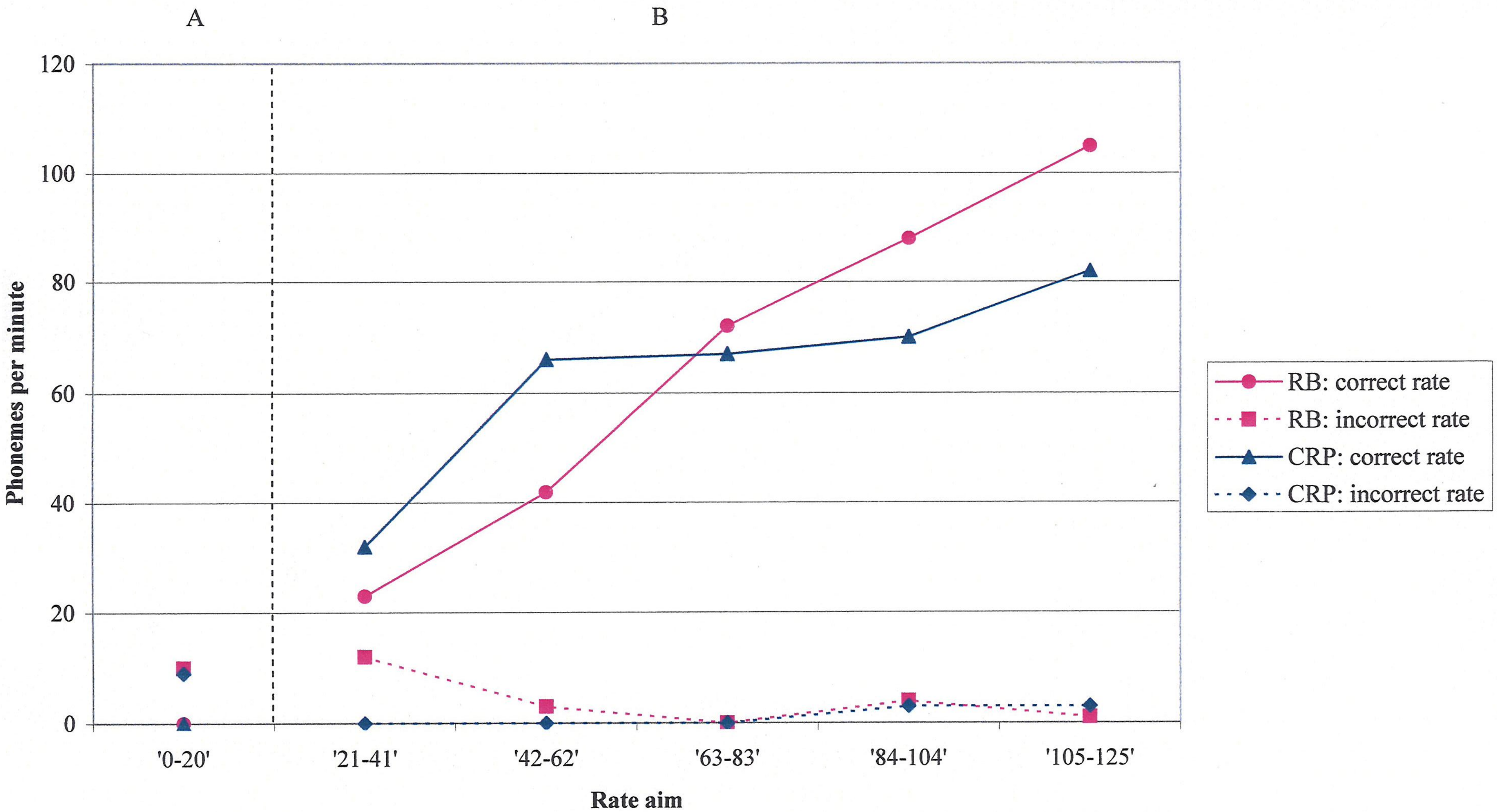

Figure 8.6: Correct and incorrect rates on the one-minute timings in the RB and CRP conditions for Ryan

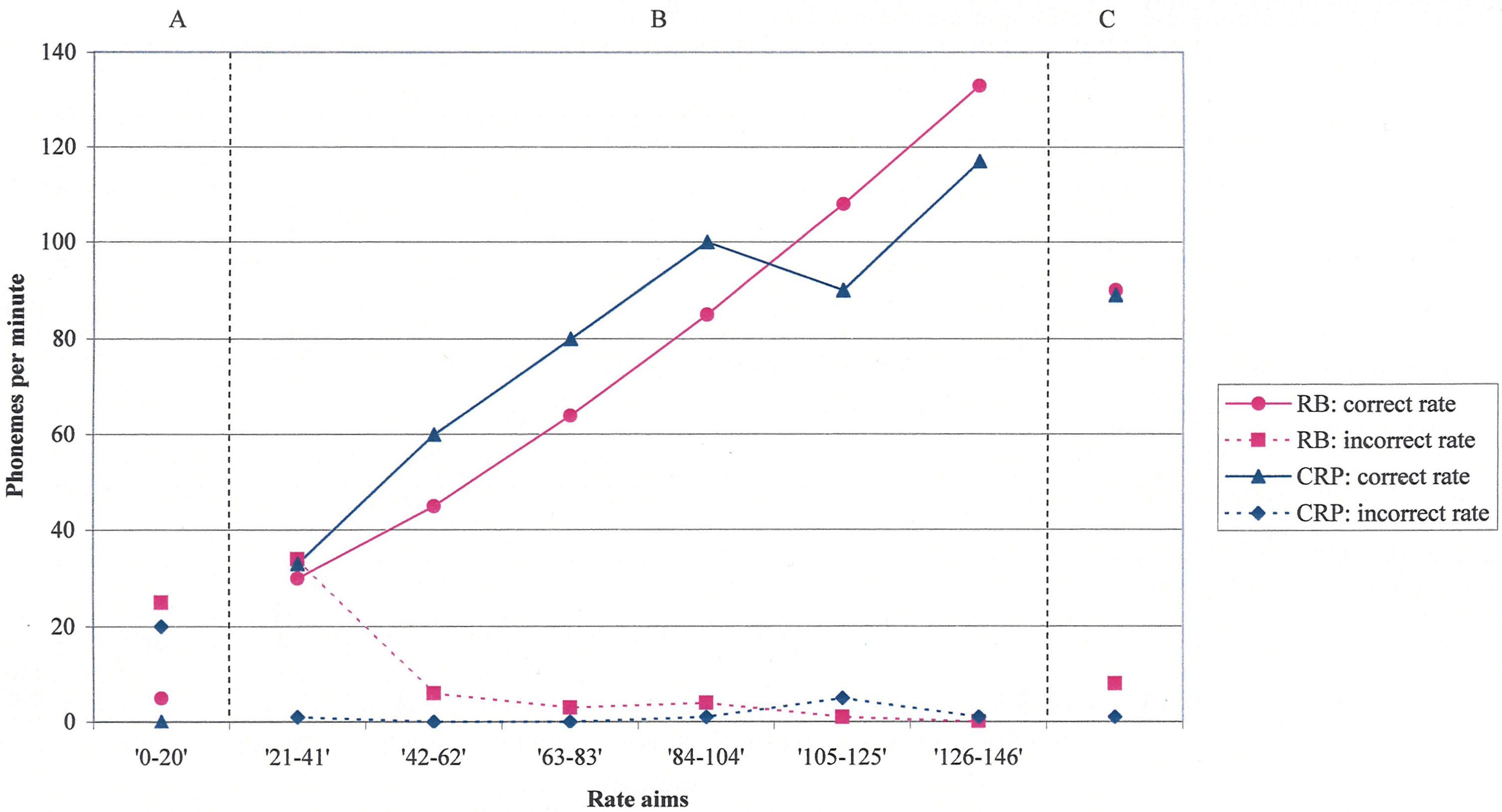

Figure 8.7: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for Troy

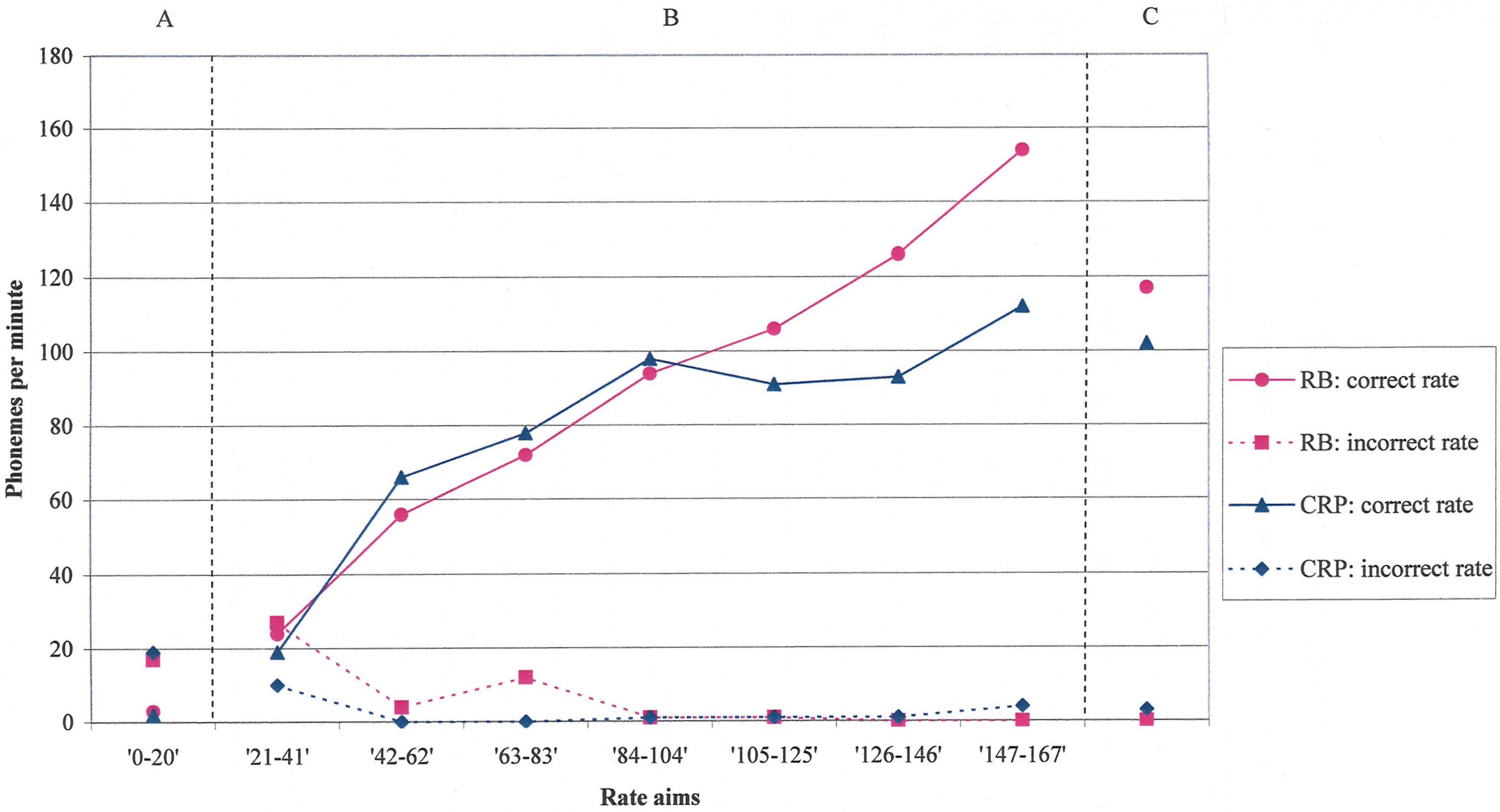

Figure 8.8: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for Wesley

Table 8.2: Mean correct and incorrect see/say rates and standard deviations during the intervention period for participants scoring within the poor reading range.

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Liam	67.8	55.2	27.0	25.2	8.4	4.2	12.9	2.6
Ryan	66.0	63.4	29.9	16.7	4.0	1.2	4.2	1.5
Wesley	90.3	79.8	40.5	28.2	6.4	2.4	9.3	3.3
Troy	77.5	80.0	35.5	27.3	8.0	1.3	11.8	1.7
Group	75.4	69.6	9.7	10.7	6.7*	2.3*	1.7	1.2

The mean correct see/say training rates and the standard deviations are shown in Table 8.2. Three of the four participants had higher mean correct see/say rates in the RB condition than in the CRP condition during the intervention phase, with differences ranging from 2.6 to 12.6 between conditions. Troy had a slightly higher mean rate in the CRP condition than in the RB condition, although the difference between the two means was only 2.5. The group mean correct see/say rate for the RB condition was 75.4 (SD = 9.7), which was higher than the group mean for the CRP condition of 69.6 (SD = 10.7). There was no significant difference ($T = 1$, $p > 0.05$) between the two conditions.

The baseline incorrect see/say rates ranged from 10 ppm to 31 ppm in the RB condition and from 9 ppm to 33 ppm in the CRP condition. All four participants

* statistically significant difference ($T = 0$, $p < 0.05$).

demonstrated increases in incorrect see/say rates on the timing for the first intervention rate aim of 21-41 ppm as they began to build speed in the RB condition. Rapid decreases in incorrect see/say rates to low levels were then observed by the next rate aim of 42-62 ppm in the this condition. The participants maintained low incorrect see/say rates for the remainder of the intervention phase in the RB condition. In contrast, immediate decreases in incorrect see/say rates were evident on the timing for the first rate aim in the CRP condition. The participants also maintained low incorrect see/say rates in the CRP condition for the rest of the intervention period.

The mean incorrect see/say rates and standard deviations are also shown in Table 8.2. All four participants had higher mean incorrect rates in the RB condition than in the CRP condition, with differences between conditions ranging from 2.8 to 6.7. The mean group incorrect see/say rate for the RB condition was 6.7 (SD = 1.7), which was higher than the mean group rate of 2.3 (SD = 1.2) in the CRP condition. There was a significant difference between the two conditions ($T = 0$, $p < 0.05$).

The final phase in Figures 8.5 to 8.8 show the correct and incorrect see/say training rates on the follow-up tests. Only three of the original four participants were available for follow-up testing. Each of these children had higher correct rates in the RB condition compared to in the CRP condition on the follow-up see/say tests, although Troy's rates in the two conditions were very similar. All of the students showed decreases in correct rates on the follow-up tests from the intervention phase. The group mean correct rate for the RB condition was 95 (SD = 16.3) compared to a group mean rate of only 85.3 (SD = 15.3) in the CRP condition and the difference was statistically different ($T = 0$, $p < 0.05$). The incorrect rates of each of the participants had increased from the intervention phase on the follow-up tests. Two of the children had higher incorrect rates in the CRP condition on the follow-up tests, whilst one child had a higher incorrect rate in the RB condition. The group mean incorrect rates for the RB and CRP conditions were 2.7 (SD = 3.8) and 1.7 (SD = 0.9) correspondingly and there was no statistical difference between conditions ($T = 3$, $p > 0.05$).

<u>Correct and incorrect see/say training rates for the participants scoring within the average range on the TERA-3</u>

The correct rates that were demonstrated when each child achieved the rate aims in the RB condition and the corresponding rates in the CRP condition are shown in Figures 8.9 to 8.12. These figures relate to the four participants who scored within the average range on the TERA-3.

The baseline correct see/say rates ranged from 0 ppm to 7 ppm in the RB condition and from 0 ppm to 6 ppm in the CRP condition. Each participant demonstrated increases in correct rates during the period of intervention in both the RB and CRP conditions. On the timings for the first rate aim there were little differences between the participants' correct see/say rates in each condition. Lucy demonstrated a higher correct see/say rate in the RB condition by the second intervention rate aim of 42-62 ppm and maintained a higher rate in this condition than in the CRP condition for the remainder of the treatment period. The data for Tahni and Lee showed that correct see/say rates in the two conditions were initially similar for a number of rate aim timings. At the 63-83 ppm and 84-104 ppm rate aims for Tahni and Lee respectively, the data diverged and showed that the RB correct see/say training rates began to develop more rapidly than the CRP correct rates. Kyle's data

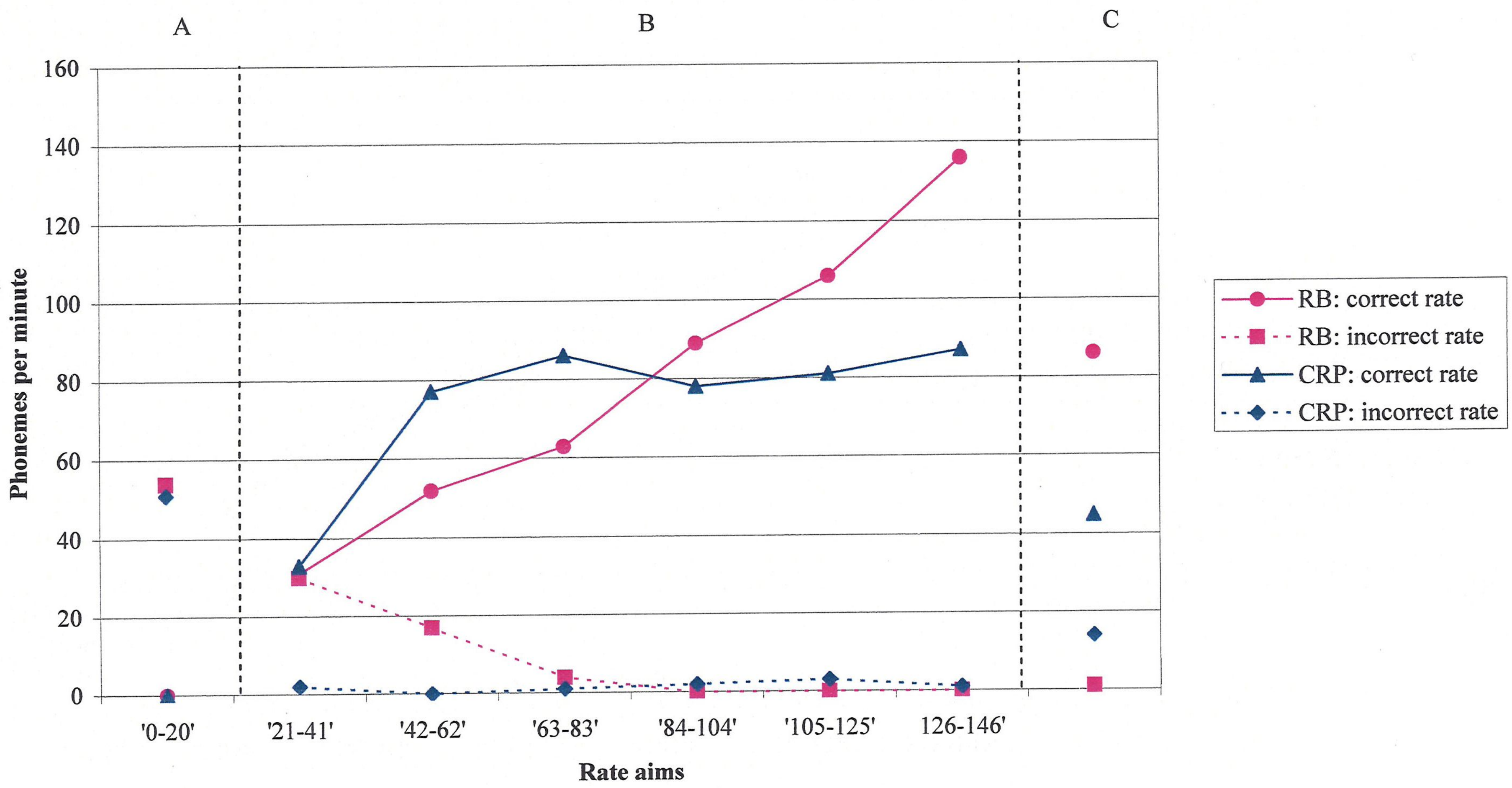

Figure 8.9: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for Kyle

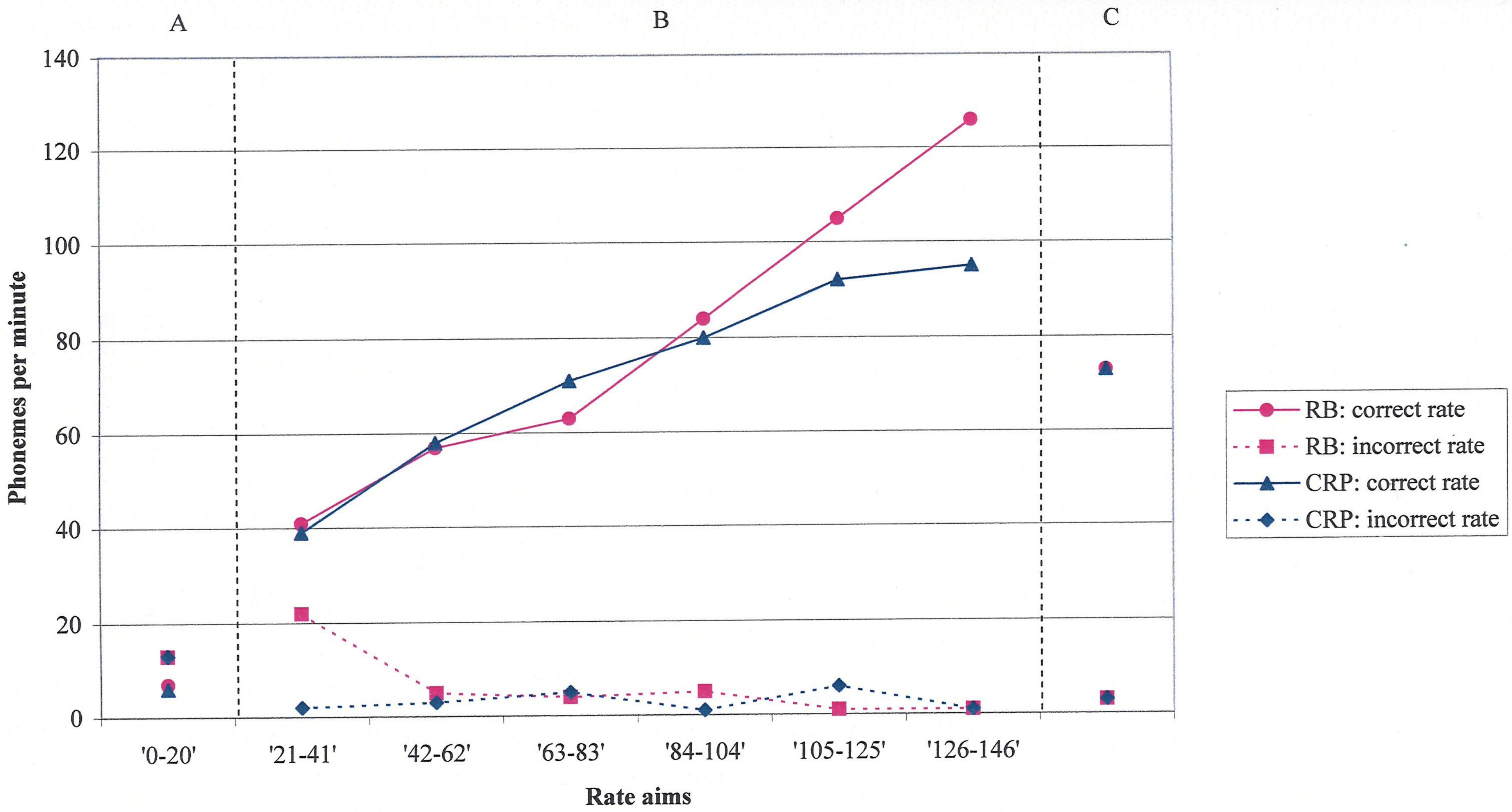

Figure 8.10: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for Lee

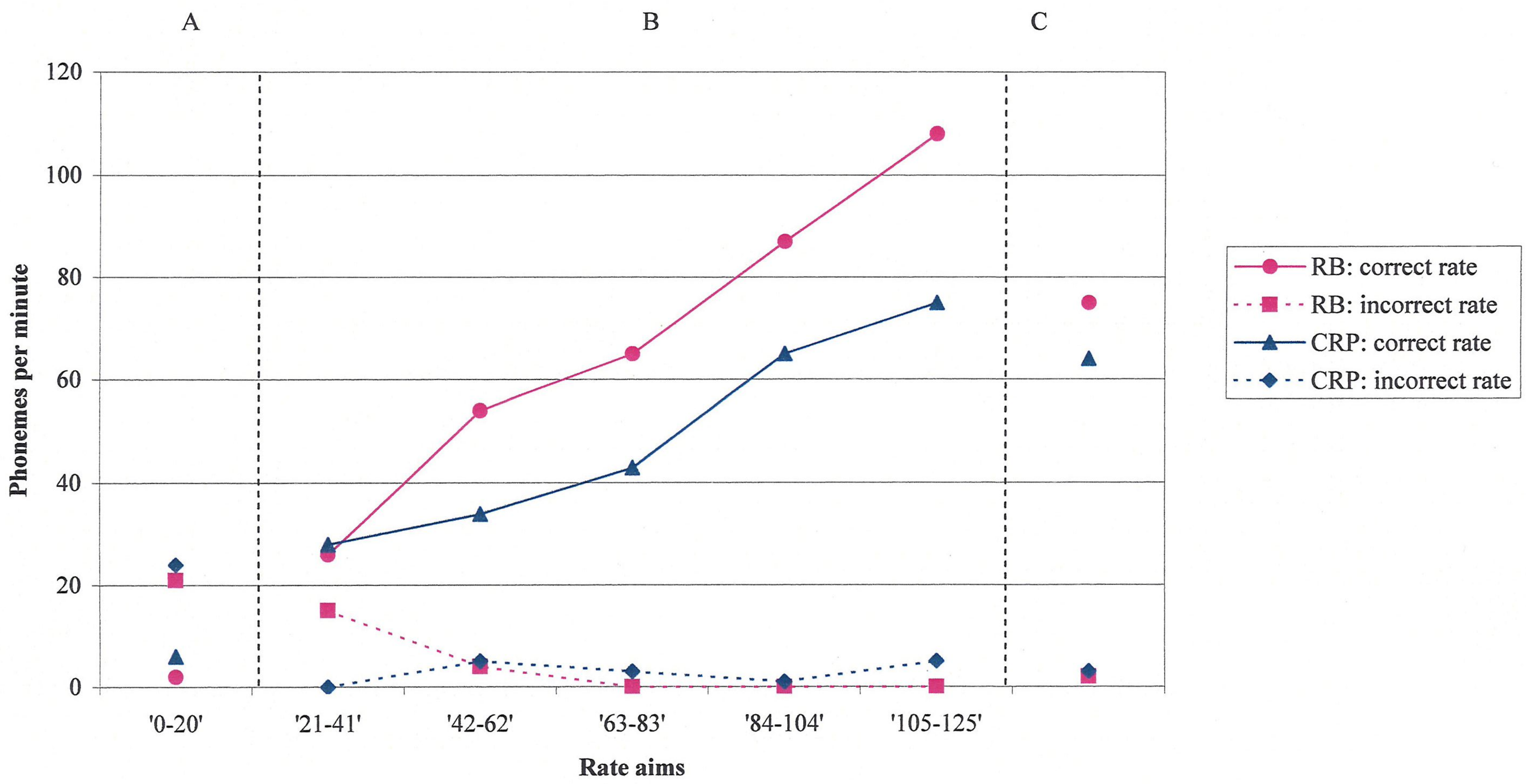

Figure 8.11: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for Lucy

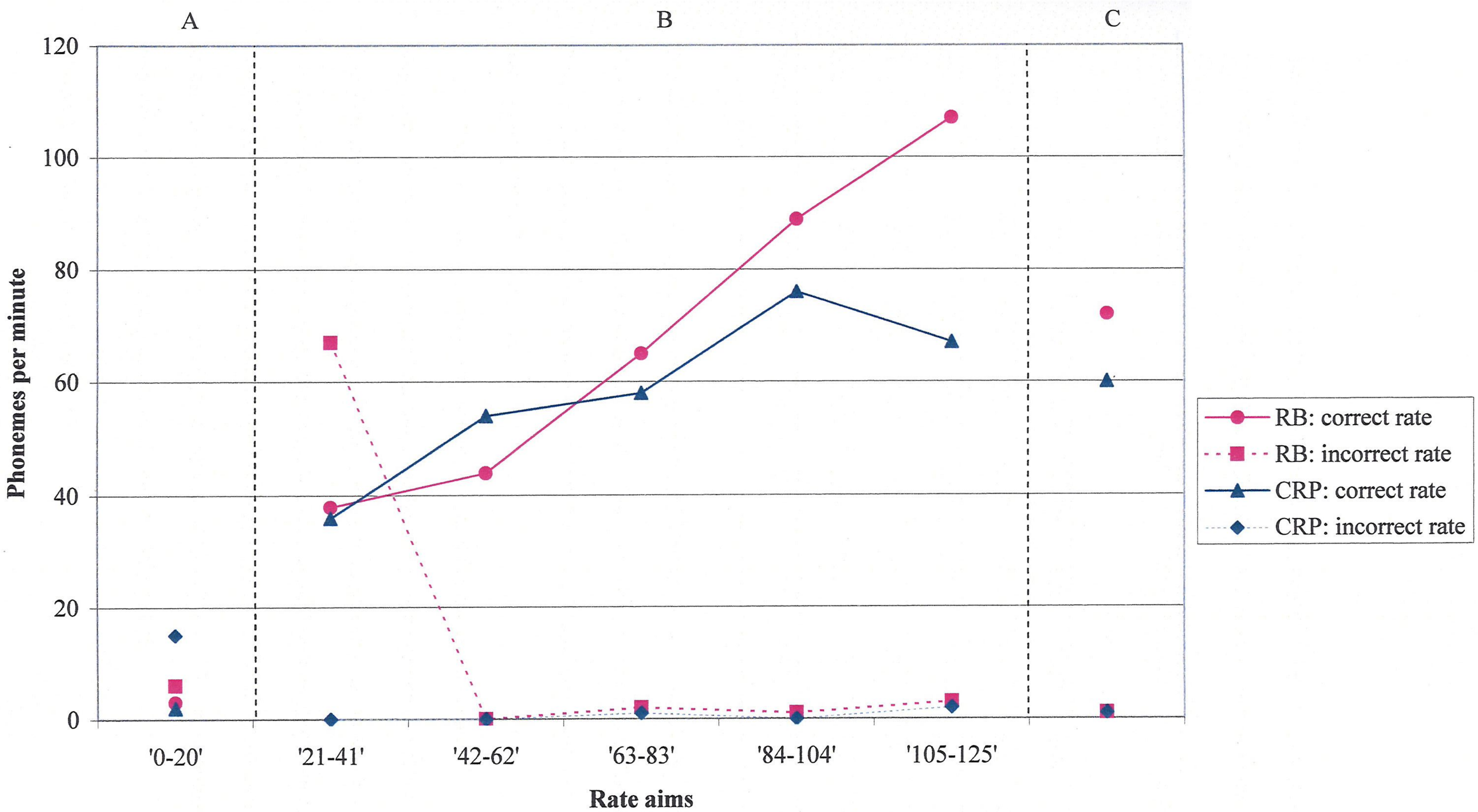

Figure 8.12: Correct and incorrect rates on the one-minute timings at each rate aim in the RB and CRP conditions for Tahni

Table 8.3: Mean correct and incorrect see/say rates and standard deviations during the intervention phase for participants scoring within the average reading range.

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Tahni	68.6	58.2	26.3	11.0	14.6	0.6	26.2	0.8
Lee	79.3	72.5	29.1	21.3	6.3	3.0	7.2	1.9
Lucy	68.0	49.0	28.0	18.1	3.8	2.8	5.8	2.0
Kyle	79.5	73.7	35.0	18.6	8.5	1.5	11.3	1.0
Group	73.9*	63.3*	5.6	10.3	8.3*	2.0*	4.0	1.0

(Figure 8.9) also intercepted and diverged at the 84-104 ppm rate aim at which point his RB correct see/say rate increased more rapidly than his CRP rate. His data differed from those of Tahni and Lee in that he initially showed much more rapid development in correct see/say rate in the CRP condition.

The mean correct see/say rates and the standard deviations for each of the participants scoring within the average range on the TERA-3 are shown in Table 8.3. All four participants had higher mean correct rates in the RB condition than in the CRP condition with differences between the means in the two conditions ranging from 5.8 to 19. The mean group correct see/say rate for the RB condition was 73.9 (SD = 5.6), which was higher than the group mean for the CRP condition of 63.3 (SD = 10.3). A significant difference was found between the two conditions ($T = 0$, $p < 0.05$).

* statistically significant difference ($T = 0$, $p < 0.05$).

Incorrect see/say rates ranged from 6 ppm to 54 ppm in the RB condition and from 13 ppm to 51 ppm in the CRP condition. Incorrect see/say rates increased for Tahni and Lee as they initially began to build speed in the RB condition. Tahni showed dramatic increases in her incorrect see/say rate on the timing for the first rate aim of 21-41 ppm in the RB condition, whilst Lee demonstrated a smaller increase. The remaining two participants showed immediate decreases in incorrect see/say rates in the RB condition. Immediate and more rapid decreases in incorrect see/say rates were evident for each of the participants in the CRP condition. However, the rates in the two conditions remained at similar low levels for the remainder of the intervention period after the 42-62 ppm rate aim.

The mean incorrect see/say rates and standard deviations for each of the participants are also shown in Table 8.3. All participants had higher mean incorrect see/say rates in the RB condition than in the CRP condition. The group mean incorrect rate for the RB condition was 8.3 ($\underline{SD}$ = 4.0), which was higher than the group mean of 2.0 ($\underline{SD}$ = 1.0) in the CRP condition. There was a significant difference between the RB and CRP conditions ($T = 0$, $p<0.05$).

The correct and incorrect see/say rates on the follow-up tests are shown in the final phase of Figures 8.9 to 8.12. Three of the participants had higher correct rates in the RB condition than in the CRP condition on the follow-up tests. Lee had equal correct rates in the two conditions on these tests. The group mean correct rate was 76.5 ($\underline{SD}$ = 5.6) for the RB condition and for the CRP condition the group mean correct rate was 60.5 ($\underline{SD}$ = 10.1) and the different between conditions was statistically significant ($T = 0$, $p < 0.05$). The incorrect rates on the follow-up tests were similar to those evident in the intervention phase for most of the participants. Only Kyle's CRP incorrect rate showed a significant increase from the intervention phase. The group mean incorrect rate was higher in the CRP condition at 5.3 (SD = 5.1) than in the RB condition for which the group mean was 1.8 (SD = 0.8). There was a statistically significant difference between conditions ($T = 0$, $p < 0.05$)

Rates on the RESAA probes

Figures 13.1 to 13.108 relate to the data described in this section and are shown in Appendix 11. The figures show the participants' correct and incorrect rates at each rate aim for the RESAA probes. In addition, the figures also show the correct see/say rates attained by the participants at each rate aim in the RB condition during training. In this section the children's correct and incorrect rates on the RESAA probes will be reported. The following section will compare the see/say rates on the one-minute timings in the RB condition with RESAA rates at each rate aim over the intervention period in the RB condition.

Retention rates

The retention probes were conducted throughout the intervention, one week after a period of no practice, following a participant's attainment of a rate aim in the RB condition or completion of the required number of phoneme repetitions in the CRP condition. The rates on these short-term retention probes are shown in Figures 13.1 to 13.12. Three months after the termination of the intervention the long-term follow-up retention tests were conducted. These data are shown in the final phases of Figures 13.1 to 13.12. These long-term retention assessed the retention of see/say training rates and, thus, they were also included in the see/say training rate figures and described in the previous section.

<u>Retention rates for participants scoring within the very poor range on the TERA-3.</u>

Retention rate data are shown in Figures 13.1 to 13.4 in Appendix 11 for the participants scoring within the very poor range on the TERA-3. Two participants demonstrated consistently higher correct see/say rates in the RB condition than in the CRP condition on the retention probes. One participant initially attained a higher rate in the latter condition at the first rate aim but achieved and maintained higher correct see/say rates in the RB condition after this timing. Aaron's retention rates were more variable.

The mean correct see/say rates on the retention probes for each of the participants scoring within the very poor range on the TERA-3 are shown in Table 8.4. All four participants had higher mean correct retention rates in the RB condition than in the CRP condition, although there were only slight differences between the means in the two conditions for three of the children. The mean group rate of 49.6 (<u>SD</u> = 6.0) for the RB condition was slightly higher than the mean group rate for the CRP condition, which was 41.0 (<u>SD</u> = 11.6). There was a significant difference between the two conditions ($T = 0$, $p < 0.05$).

The mean incorrect see/say rates on the retention probes are also shown for each participant in Table 8.4. Three children had slightly higher mean incorrect see/say rates in the RB condition than in the CRP condition, whilst one had a higher mean incorrect rate in the CRP condition. However, the differences between the means in the two conditions differed only slightly for three of the students. The mean group incorrect see/say rate on the retention probes for the RB condition was 7.1 (<u>SD</u> = 2.8) and for the CRP condition it was 5 (<u>SD</u> = 1.2). There was no significant difference ($T = 2$, $p > 0.05$).

Table 8.4: Mean correct and incorrect retention rates for participants scoring within the very poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Aaron	58.8	56.7	13.0	12.8	5.3	5.8	5.4	5.1
Christopher	48.6	41.6	17.4	9.3	3.4	3.2	2.9	1.1
James	48.8	41.6	18.8	11.9	9.0	6.2	15.5	3.1
Sean	42.0	24.0	19.4	6.4	10.5	4.8	14.2	2.7
Group	49.6*	41.0*	6.0	11.6	7.1	5.0	2.8	1.2

Retention rates for participants scoring within the poor reading range on the TERA-3.

Figures 13.5 to 13.8 in Appendix 11 show the retention rate data for the four participants scoring within the poor range on the TERA-3. Each of the children initially showed higher correct retention rates in the CRP condition at a number of rate aims until the 84-104 ppm aim for Liam, Wesley and Ryan and until the 105-125 ppm aim for Troy, at which point the RB data intercepted the CRP data. Divergences in data were then evident as the RB retention rates for the children increased more rapidly than the CRP rates.

Table 8.5: Mean correct and incorrect retention rates for participants scoring within the poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Liam	67.4	61.0	25.7	23.0	3.8	2.2	5.2	4.4
Ryan	63.2	70.0	30.0	20.1	2.0	2.4	2.1	1.4
Troy	71.5	78.5	33.8	27.5	7.8	1.8	12.7	1.8
Wesley	88.7	84.9	40.9	31.0	3.9	1.1	6.6	1.1
Group	72.7	73.6	9.7	9.0	4.4	1.9	2.1	0.5

The mean correct and incorrect see/say rates on the retention probes and the standard deviations are shown in Table 8.5. Two of the participants had higher correct see-say rates on the retention probes in the RB condition than in the CRP condition whilst for the remaining two children the reverse was observed. Differences between the rates in the two conditions ranged from 3.9 to 7 across all four participants. The group mean correct see/say rate for the retention probes of 73.6 (SD = 9.0) in the CRP condition was slightly higher than the group mean in the RB condition, which was 72.7 (SD = 9.7). There was no significant difference between the retention rates in the two conditions ($T = 3$, $p > 0.05$).

Mean incorrect retention rates were higher in the RB condition than in the CRP condition for three of the participants. Each participant had a higher incorrect rate in the RB condition on the timing for the first intervention rate aim, after which the data were similar in the two conditions for the remainder of the intervention period for each child. The group mean incorrect see/say rate for the retention probes was 4.4 (<u>SD</u> = 2.1) in the RB condition compared to 1.9 (<u>SD</u> = 0.5) in the CRP condition. There was no significant difference between participant rates in the two conditions ($T = 1$, $p > 0.05$).

<u>Retention rates for the participants scoring within the average reading range on the TERA-3.</u>

The correct and incorrect see/say rates on the retention probes for the children scoring within the average range on the TERA-3 are shown in Figures 13.9 to 13.12 in Appendix 11. Lucy maintained higher correct see/say rates on the retention probes in the RB condition than in the CRP condition for the intervention period after the first intervention rate aim. Tahni and Kyle initially demonstrated higher correct rates in the CRP condition on the retention probes until the 84–104 ppm and 63–83 ppm rate aims respectively, after which their RB rates exceeded their CRP rates. Lee showed very similar correct see/say rates in the two conditions until the data diverged at the 84 – 104 ppm rate aim.

The mean correct see/say rates on the retention probes for the average readers are shown in Table 8.6. Three of the participants achieved higher mean correct rates on the retention probes in the RB condition than in the CRP condition. The group mean retention rate in the RB condition was 69.2 (<u>SD</u> = 8.3), which was slightly higher than the group mean for the CRP condition of 66.3 (<u>SD</u> = 10.1). There was no significant difference between the rates in the two conditions ($T = 3$, $p > 0.05$).

Table 8.6: Mean correct and incorrect retention rates for participants scoring within the average reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Kyle	69.2	76.4	27.5	9.1	12.6	2.0	13.3	0.9
Lee	82.2	76.2	23.3	12.3	3.0	2.3	3.7	1.1
Lucy	65.8	58.0	27.3	11.3	3.6	4.2	3.7	3.1
Tahni	59.6	54.6	27.0	12.2	6.2	1.4	10.5	0.8
Group	69.2	66.3	8.3	10.1	6.4	2.5	3.8	1.0

Incorrect see/say rates on the retention probes were initially higher in the RB condition than in the CRP condition at the first intervention rate aim for three of the participants and for the first two rate aims for Kyle. Incorrect retention rates in the RB condition then decreased and remained at similar levels to the incorrect retention rates in the CRP condition for the remainder of the intervention period.

The mean incorrect see/say rates on the retention probes for each child are also shown in Table 8.6. Three of the participants had higher mean incorrect rates in the RB condition than in the CRP condition. The group mean incorrect rate for the RB condition was 6.4 (SD = 3.8) and for the CRP condition it was 2.5 (SD = 1.0). There was no significant difference between the incorrect retention rates in the two conditions ($T = 0$, $p > 0.05$).

Endurance rates

Endurance probes were conducted during the baseline phase and during the intervention phase after each participant had reached a specific rate aim in the RB condition or had completed the same number of practice repetitions in the CRP condition. Rates were assessed over three minutes on the endurance probes and scores were converted to per minute rates. The follow-up endurance tests were then conducted three months after the intervention was completed.

Endurance rates for the participants scoring within the very poor reading range on the TERA-3.

Figures 13.13 to 13.16 in Appendix 11 show the correct and incorrect endurance rates for the participants scoring within the very poor reading range on the TERA-3. The endurance baseline measures revealed correct see/say rates to be very low, ranging from 0 ppm to 2 ppm in both conditions. Increases in correct see/say rates on the endurance probes were evident for each of the participants. Sean demonstrated consistently higher correct endurance rates in the RB condition than in the CRP condition over the entire treatment period. For the remaining three children correct rates in the two conditions were comparable for a number of target training rates until the data diverged after the 84-104 ppm rate aim for James and Aaron and after the 42-62 ppm rate aim for Christopher and then correct endurance rates remained higher in the RB condition for the remainder of the intervention period.

The mean correct endurance rates for each participant are shown in Table 8.7. All of the participants had higher mean correct see/say rates in the RB condition than in the CRP condition on the endurance probes. Differences between the rates in the two

Table 8.7: Mean correct and incorrect endurance rates for participants scoring within the very poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Aaron	61.7	53.0	27.2	17.0	6.3	2.8	7.6	4.2
Christopher	53.2	47.0	25.3	18.0	2.8	2.8	3.1	2.0
James	49.4	40.4	23.7	11.5	8.0	4.4	13.5	2.7
Sean	39.3	21.5	13.6	11.1	6.8	3.0	8.9	2.0
Group	50.9*	40.5*	8.1	11.8	6.0*	3.3*	1.9	0.7

conditions ranged from 6.2 to 17.8. The group mean correct see/say rate for the endurance probes for the RB condition was 50.9 (SD = 8.1), which was higher than the group mean of 40.5 (SD = 11.8) for the CRP condition. There was a significant difference between the participants' correct see/say rates on the endurance probes (T= 0, $p < 0.05$).

Incorrect see/say rates on the baseline endurance measures ranged from 3 ppm to 36 ppm in the RB condition and from 4 ppm to 23 ppm in the CRP condition. Aaron and Christopher demonstrated immediate decreases in incorrect rates in both conditions, although their incorrect rates were very slightly higher in the RB condition than in the CRP condition at a number of rate aims. Their incorrect rates remained at low levels in the two conditions on the endurance probes over the intervention period. James and Sean initially showed rapid increases in incorrect rates on the first endurance probe in the intervention

* statistically significant difference (T = 0, $p < 0.05$)

phase in the RB condition. However, the incorrect rates on the following endurance probe decreased dramatically for both participants in this condition and remained at the low levels observed in the CRP condition for the following endurance probes.

The mean incorrect see/say rates on the endurance probes for each of the participants are also shown in Table 8.7. Mean incorrect rates were higher in the RB condition for three children and for the remaining child the mean rates were equal in the two conditions. The group mean incorrect rate on the endurance probes for the RB condition was 6.0 (SD = 1.9), which was slightly higher than the group mean of 3.3 (SD = 0.7) for the CRP condition. A significant difference was found between the students' incorrect endurance rates in the two conditions ($T = 0$, $p < 0.05$).

The follow-up endurance data are shown in the final phases of Figures 13.13 to 13.16. Aaron and James showed decreases in correct endurance rates on the follow-up tests from the baseline phase, although some retention of the endurance rates was evident. Aaron had a higher correct endurance rate in the RB condition whilst James performed at a rate that was 1 ppm higher in the CRP condition than in the RB condition on the endurance follow-up tests. The group mean correct endurance rate for the follow-up tests was 54 (SD = 8) for the RB condition and 51.5 (SD = 4.5) for the CRP condition. Aaron's incorrect rates were similar on the endurance follow-up tests to his rates during the intervention period in both conditions. James showed increases in incorrect rates in both conditions from the intervention probes to the follow-up tests. The group mean incorrect rate was slightly higher at 6 (SD = 6) in the RB condition compared to the group mean of 5.5 (SD = 4.5) in the CRP condition. There was statistical difference between conditions ($T = 1$, $p > 0.05$).

Endurance rates for the participants scoring within the poor reading range on the TERA-3.

The data regarding correct and incorrect see/say rates on the endurance probes for the participants scoring within the poor reading range on the TERA-3 are shown in Figures 13.17 to 13.20 in Appendix 11. The baseline endurance measures indicated correct see/say rates were very low, ranging from 0 ppm to 6 ppm in the RB condition and from 0 ppm to 4 ppm in the CRP condition. Each child showed increases in correct rates on the endurance probes in both conditions over the period of intervention. Wesley demonstrated higher correct rates in the RB condition than in the CRP condition on most of the endurance probes. More rapid increases in correct endurance rates were initially evident in the CRP condition for Liam, Ryan and Troy, whilst the RB data showed a more gradual increase. However, at the 84-104 ppm rate aim for Liam and Ryan and at the 105-125 ppm rate aim for Troy the data diverged as the RB rates began to increase more rapidly than the CRP rates.

The mean correct endurance rates for each of the participants are shown in Table 8.8. Two children had higher mean correct see/say rates on the endurance probes in the RB condition than in the CRP condition, whilst the remaining two individuals had higher mean rates in the latter condition. The group mean correct rate on the endurance probes for the RB condition was 67.0 ($\underline{SD}$ = 9.4), which was slightly higher than the group mean of 64.1 ($\underline{SD}$ = 6.7) for the CRP condition. There was no significant difference between the students' rates in the two conditions ($T = 0$, $p > 0.05$).

Incorrect endurance rates ranged from 11 ppm to 29 ppm in the RB condition and from 10 ppm to 21 ppm in the CRP condition. Wesley demonstrated immediate decreases

Table 8.8: Mean correct and incorrect endurance rates for participants scoring within the poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Liam	60.8	55.0	27.9	21.4	6.0	3.2	8.5	4.5
Ryan	57.6	60.4	28.8	18.2	3.8	1.6	3.7	0.8
Troy	67.5	70.8	30.4	25.0	8.3	2.1	12.5	1.6
Wesley	82.0	70.3	34.6	27.3	4.0	2.1	6.6	2.2
Group	67.0	64.1	9.4	6.7	5.5*	2.3*	1.8	0.6

in incorrect rates on the endurance probes in both conditions, whilst the other participants only showed decreases in the CRP condition on the first endurance probes in the intervention period. However, after the initial endurance probes in the treatment period the children's incorrect rates in the two conditions were similar and remained at low levels for the remainder of the intervention phase.

The mean incorrect endurance rates for each child are also shown in Table 8.8. All participants had higher mean incorrect rates in the RB condition than in the CRP condition. The group mean incorrect endurance rate for the RB condition was 5.5 (SD = 1.8) compared to 2.3 (SD = 0.6) for the CRP condition. There was a significant difference between the children's rates in the two conditions ($T = 0$, $p < 0.05$).

* statistically significant difference ($T = 0$, $p < 0.05$).

The endurance follow-up probes showed that two of the participants achieved higher correct rates in the CRP condition whilst one attained a higher rate in the RB condition. The group mean correct rate for the endurance follow-up probes was 84 (SD = 14.5), which was slightly lower than the group mean of 86.7 (SD = 9.0) in the CRP condition. There was no statistical difference between conditions ($T = 1$, $p > 0.05$). The incorrect rates on the endurance follow-up tests remained at levels similar to those observed during the intervention phase. The group mean incorrect rates on the endurance follow-up probes were equal in the two conditions ($M = 1$; $SD = 0.8$) and there was a statistical difference between conditions ($T = 0$, $p < 0.05$).

Endurance rates for the participants scoring within the average reading range on the TERA-3.

Figures 13.21 to 13.24 show the correct and incorrect endurance rates for the children who scored within the average reading range on the TERA-3. The baseline correct see/say rates on the endurance probes were low, ranging from 0 ppm to 16 ppm in the RB condition and from 0 ppm to 6 ppm in the CRP condition. Lucy demonstrated consistently higher correct see/say rates in the RB condition after the first intervention endurance probe. Tahni and Kyle had consistently higher endurance rates in the CRP condition until the 84-104 ppm rate aim after which they demonstrated higher rates in the RB condition for the final one and two probes in the intervention period respectively. Liam showed comparable correct see/say rates on the endurance probes in the two conditions over the period of intervention.

Table 8.9: Mean correct and incorrect endurance rates for participants scoring within the average reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Kyle	70.8	70.2	24.7	7.3	5.8	1.5	12.2	1.0
Lucy	62.8	51.0	25.6	14.9	5.0	2.4	8.0	0.8
Liam	65.0	67.7	26.0	16.1	4.3	2.8	4.9	0.7
Tahni	53.4	55.8	20.8	12.8	5.2	1.0	6.5	0.6
Group	63.0	61.2	6.3	8.0	5.1*	1.9*	0.5	0.7

The mean correct see/say rates on the endurance probes for each participant during the intervention period are shown in Table 8.9. Two individuals had higher mean correct rates on the endurance probes in the RB condition than in the CRP condition and the two remaining students had higher mean rates in the latter condition. The group mean correct rate was slightly higher in the RB condition and was 63.0 (SD = 6.3). The CRP group mean was 61.2 (SD = 8.0). There was no significant difference between the participants' correct endurance rates in the two conditions ($T = 0$, $p > 0.05$).

The endurance baseline measures revealed incorrect see/say rates to range from 20 ppm to 61 ppm in the RB condition and from 20 ppm to 45 ppm in the CRP condition. All participants showed immediate decreases in incorrect rates in both conditions during the

* statistically significant difference ($T = 0$, $p < 0.05$).

intervention period, although more rapid decreases were initially observed in the CRP condition on the first endurance probe. However, the incorrect rates for each of the participants decreased to similar low levels in the two conditions after the first endurance probe for the remainder of the treatment period.

The mean incorrect rates for each of the children on the endurance probes are also shown in Table 8.9. The participants each had higher mean incorrect endurance rates in the RB condition than in the CRP condition. The group mean incorrect rate of 5.1 ($\underline{SD}$ = 0.5) was also higher in the RB condition. The CRP group incorrect mean was 1.9 ($\underline{SD}$ = 0.7). There was a significant difference between the children's mean incorrect endurance rates in the two conditions ($T = 0$, $p < 0.05$).

The endurance follow-up probes showed that three of the students attained higher correct rates in the RB condition than in the CRP condition whilst the remaining child achieved a higher rate in the latter condition. The group mean correct rate on the endurance follow-up probes was 75 ($\underline{SD}$ = 6.8) for the RB condition, which was higher than the group mean for the CRP condition of 64.8 ($\underline{SD}$ = 11.0). There was no significant difference between conditions ($T = 1$, $p > 0.05$).

Visual stability

The VS probes involved the participants reading the phonemes for one minute whilst a child's movie played with no sound on a screen in front of their desks. The VS probes were conducted during the baseline phase and were also administered when each participant reached a specific rate aim in the RB condition or completed an equal number of practice repetitions in the CRP condition. The follow-up VS probes were conducted three months after the intervention was completed.

Visual stability rates for the participants scoring within the very poor reading range on the TERA-3.

The VS baseline measures showed that correct see/say rates were very low at 0 ppm for each child in the RB condition and ranged from 0 ppm to 6 ppm in the CRP condition (Figures 13.25 to 13.28, Appendix 11). Increases in correct rates on the VS probes were evident in both conditions over the intervention period. However, the rates were consistently higher in the RB condition than in the CRP condition for three of the participants. For the remaining student, his correct rates were initially slightly higher in the CRP condition on the first probe but were higher in the RB condition for all remaining probes in the treatment period.

The mean correct rates on the VS probes are shown for each child in Table 8.10. All four participants had much higher mean correct rates in the RB condition than in the CRP condition on the VS probes. Differences between the participants' mean rates in the two conditions ranged from 17 to 29.5. The group mean correct rate for the VS probes was 61.3 ($\underline{SD}$ = 12.2) for the RB condition compared to only 39.8 ($\underline{SD}$ = 15.9) for the CRP condition. A significant difference was found between the children's mean rates in the two conditions ($T = 0$, $p < 0.05$).

The incorrect see/say rates on the VS probes are shown in Figures 13.25 to 13.28 in Appendix 11. Baseline incorrect rates ranged from 8 ppm to 59 ppm in the RB condition and from 6 ppm to 33 ppm in the CRP condition on the VS probes. Increases in incorrect rates were initially observed in the RB condition on the first probe for two of the children before these rates began to decline. Their CRP rates declined over the entire intervention period. The other two participants demonstrated immediate decreases in their incorrect ble 8.10: Mean correct and incorrect visual stability rates for participants scoring within the very poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
ıron	80.0	61.8	30.9	20.6	7.0	3.3	13.4	4.8
ıristopher	62.0	40.8	23.3	12.7	4.4	2.4	6.8	1.4
nes	56.6	39.6	27.0	17.4	11.8	3.2	19.2	1.5
an	46.5	17.0	21.1	8.6	6.5	2.0	6.7	1.2
oup	61.3*	39.8*	12.2	15.9	7.4*	2.73*	2.7	0.5

es in both conditions. The participants' mean incorrect rates on the VS probes are also own in Table 8.10. Each child had a higher mean incorrect rate in the RB condition mpared to in the CRP condition. The group mean incorrect rate for the VS probes was ł (SD = 2.7) in the RB condition which was higher than the group mean of 2.7 (SD = 0.6) the CRP condition. A significant difference was found between the participants' rates the two conditions ($T = 0$, $p < 0.05$).

The follow-up VS probe data are shown in the final phases of Figures 13.25 to .28 (Appendix 11). Aaron and James demonstrated decreases in correct VS rates from intervention phase to the follow-up tests. However, some retention of VS rates was ident for both participants. Each child showed higher correct rates in the RB condition ın in the CRP condition on the VS follow-up tests. The group mean correct rate for the

atistically significant difference ($T = 0$, $p < 0.05$).

VS follow-up tests was 60.5 (SD = 10.5) for the RB condition and for the CRP condition it was 55.5 (SD = 6.5). The difference between conditions was statistically significant ($T = 0$, $p < 0.05$). The VS incorrect rates increased slightly for both participants in the two conditions from the intervention phase to the follow-up tests. The group mean incorrect rate was 7 (SD = 3) for the RB condition and 9 (SD = 2) for the CRP condition and the difference was statistically significant ($T = 0$, $p < 0.05$).

Visual stability rates for the participants scoring within the poor reading range on the TERA-3.

Figures 13.29 to 13.32 show the correct and incorrect see/say rates on the VS probes for the participants scoring within the poor range on the TERA-3. The VS baseline correct rates ranged from 0 ppm to 4 ppm in the RB condition and from 0 ppm to 5 ppm in the CRP condition. Increases in correct VS rates were evident in both conditions over the intervention period.

The mean VS correct rates for each of the children are shown in Table 8.11. Two of the participants had higher mean correct rates in the RB condition, whilst the remaining two had higher mean rates in the CRP condition on the VS probes. Differences between the means in the two conditions ranged from 2.2 to 10.7. The group mean correct rates on the VS probes were very similar at 73.8 (SD = 14.4) for the RB condition and 73 (SD = 10.4) for the CRP condition. There was no significant difference between the participants' mean correct rates ($T = 5$, $p > 0.05$).

The baseline incorrect see/say rates on the VS probes ranged from 10 ppm to 43 ppm in the RB condition and from 11 ppm to 38 ppm in the CRP condition. Incorrect rates on the VS probes decreased to low levels in both conditions over the intervention

Table 8.11: Mean correct and incorrect visual stability rates for participants scoring within the poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Liam	64.6	62.4	25.7	24.1	4.2	2.0	6.6	3.1
Ryan	58.0	63.0	28.9	12.1	2.0	1.6	3.5	0.8
Troy	76.5	81.3	35.4	37.3	6.7	0.1	11.3	0.4
Wesley	96.0	85.3	40.1	30.7	3.7	2.4	7.1	4.8
Group	73.8	73.0	14.4	10.4	4.2*	1.6*	1.7	0.9

period. Each child had a higher incorrect rate in the RB condition than in the CRP condition (Table 8.11) on the VS probes. The group mean incorrect rate was 4.2 (SD = 1.7) for the RB condition and 1.6 (SD = 0.9) for the CRP condition. There was a significant difference between the participants' mean rates in the two conditions ($T = 0$, $p < 0.05$).

Each student demonstrated higher correct rates on the VS follow-up probes in the RB condition than in the CRP condition. The group mean correct rate for the VS follow-up probes was 107 (SD = 17.9) in the RB condition. The group mean was lower in the CRP condition at 91.3 (SD = 12.0) on the follow-up tests. The difference between the conditions was statistically significant ($T = 0$, $p < 0.05$). Liam and Wesley demonstrated incorrect rates that were low and similar to those observed during the intervention phase on

* statistically significant difference ($T = 0$, $p < 0.05$).

the follow-up tests. Troy showed slight increases in his incorrect rates from the intervention phase to the follow-up phase. The group mean incorrect rate for the RB condition was 2 (SD = 2.1) and for the CRP condition it was 3 (SD = 2.9). The difference between conditions was statistically significant ($T = 0$, $p < 0.05$).

Visual stability rates for the participants scoring within the average reading range on the TERA-3.

The correct and incorrect see/say rates on each of the VS probes for children scoring within the average range on the TERA-3 are shown in Figures 13.33 to 13.36. Correct rates ranged from 0 ppm to 18 ppm in the RB condition and from 0 ppm to 10 ppm in the CRP condition for the baseline measures. Increases in correct VS rates were evident in both conditions over the intervention period. For most participants the correct see/say rates were comparable in the two conditions over the intervention phase.

The mean correct see/say rates on the VS probes are shown for each participant in Table 8.12. Each of the children had a higher mean VS correct rate in the RB condition than in the CRP condition. The group mean correct rate for the RB condition was 72.5 (SD = 6.18) and for the CRP condition it was 68.1 (SD = 9.45). There was a significant difference between the participants' rates in the two conditions ($T = 0$, $p < 0.05$).

The baseline measures revealed that incorrect see/say rates on the VS probes ranged from 15 ppm to 59 ppm in the RB condition and from 17 ppm to 68 ppm in the CRP condition. Immediate and continuing decreases in incorrect rates were evident in both conditions over the entire intervention period for three of the participants. Tahni initially showed an increase in incorrect rate on the first VS probe in the RB condition, before her incorrect rate in this condition began to decline. Each of the participants had a higher mean

Table 8.12: Mean correct and incorrect visual stability rates for participants scoring within the average reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Kyle	79.8	77.8	33.7	14.9	7.3	0.7	14.6	0.9
Lee	77.5	76.2	27.2	13.8	2.3	0.7	3.6	0.8
Lucy	66.8	63.6	28.0	12.3	3.4	1.4	5.4	1.2
Tahni	66.0	54.8	31.9	20.1	8.8	0.4	15.6	0.5
Group	72.5*	68.1*	6.2	9.5	5.5*	0.8*	2.7	0.4

incorrect rate in the RB condition than in the CRP condition on the VS probes. These means are shown in Table 8.12. The group mean incorrect rate for the RB condition was 5.5 (SD = 2.7) compared to only 0.8 (SD = 0.4) in the CRP condition. There was a significant difference between the children's mean rates in the two conditions ($T = 0$, $p < 0.05$).

The VS follow-up data are shown in the final phases of Figures 13.33 to 13.36. Three of the children attained higher correct rates in the RB condition than in the CRP condition. Lee performed at a correct rate that was slightly higher in the latter condition than in the former. The group mean correct rate for the VS follow-up probes was 88.5 (SD = 5.6) in the RB condition. There was no statistical difference between the two conditions ($T = 1$, $p > 0.05$). The group mean was lower in the CRP condition at 74 (SD = 16.1). The

* statistically significant difference ($T = 0$, $p < 0.05$).

group mean incorrect rates for the VS follow-up probes were 1.8 (SD = 0.4) for the RB condition and 4.8 (SD = 4.21) for the CRP condition. The difference between conditions was statistically significant ($T = 0$, $p < 0.05$).

Auditory Stability rates

The AS probes were one-minute in duration and involved the participants reading the phonemes whilst the sound track of the movie was played without the picture.

Auditory stability rates for the participants scoring within the very poor reading range on the TERA-3.

Figures 13.37 to 13.40 show the children's correct and incorrect see/say rates on the AS probes. Correct rates were 0 ppm in the RB condition for each of the participants and ranged from 0 ppm to 6 ppm in the CRP condition. All of the children showed increases in correct AS rates over the treatment period. Each individual demonstrated higher correct rates in the RB condition than in the CRP condition for most of the AS probes during the intervention phase. All of the children had higher mean correct rates on the AS probes in the RB condition than in the CRP condition. The group means for correct see/say rates on the AS probes were 50.8 (SD = 9.8) for the RB condition and 38.1 (SD = 16.2) for the CRP condition. There was a significant difference between the participants' mean rates in the two conditions ($T = 0$, $p < 0.05$).

The baseline measures for the AS probes indicated incorrect see/say rates ranged from 6 ppm to 60 ppm in the RB condition and from 5 ppm to 35 ppm in the CRP condition. Declining trends in incorrect rates were evident in both conditions for each participant. However, Sean did initially show a marked increase in incorrect rate on the first AS probe in the RB condition before his rate began to decrease. The mean AS

Table 8.13: Mean correct and incorrect auditory stability rates for participants scoring within the very poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Aaron	74.3	60.2	33.3	23.4	6.5	4.0	9.7	5.4
Christopher	59.8	38.0	23.6	12.1	3.6	2.6	5.8	0.8
James	52.6	39.8	25.1	14.5	11.8	3.8	19.6	1.8
Sean	48.5	14.5	18.3	5.1	7.3	3.2	9.7	1.9
Group	50.8*	38.1*	9.8	16.2	7.3*	3.4*	2.9	0.5

incorrect rates for each child during the intervention period are shown in Table 8.13. All of the students had higher mean incorrect rates in the RB condition than in the CRP condition on the AS probes. The group mean incorrect rate on the AS probes was 7.3 (SD = 2.9) for the RB condition and 3.4 (SD = 0.5) for the CRP condition. There was a significant difference between the students' mean rates in the two conditions ($T = 0$, $p < 0.05$).

The correct and incorrect AS rates on the follow-up probes are shown in Figures 13.37 to 13.40 in the final phases. James and Aaron demonstrated decreases in correct rates on the AS follow-up tests from the intervention phase although some retention of AS rates were observed. Each participant had a higher correct AS rate in the RB condition than in the CRP condition on the follow-up tests. The group mean correct rate for the AS follow-up probes was higher in the RB condition at 61 (SD = 9) than in the CRP condition

* statistically significant difference ($T = 0$, $p < 0.05$).

54 (SD = 5) and the difference was statistically significant ($T = 0$, $p < 0.05$). The incorrect rates on the same tests increased from the intervention phase. The group incorrect mean for the RB condition was 8.5 (SD = 2.5) and for the CRP condition the group mean was 9 (SD = 1). The difference was not statistically significant ($T = 0$, $p < 0.05$).

Auditory stability for the participants scoring within the poor reading range on the TERA-3.

The development of correct and incorrect see/say rates on the AS probes for each of the children scoring within the poor range on the TERA-3 are shown in Figures 13.41 to 13.44 (Appendix 11). The baseline AS measures showed that the participants' correct rates ranged from 0 ppm to 6 ppm in both conditions. Increases in correct rates on the AS probes were evident in the RB and CRP conditions over the intervention period.

Mean correct see/say rates on the AS probes for each child are displayed in Table 8.14. Three participants had higher mean correct rates in the RB condition than in the CRP condition. The group mean correct rates on the AS probes were 75.8 (SD = 14.3) and 72.2 (SD = 8.8) for the RB and CRP conditions respectively. There was no significant difference found between the children's mean correct rates in the two conditions ($T = 3$, $p > 0.05$).

The incorrect see/say rates on the baseline AS probes ranged from 9 ppm to 45 ppm and from 11 ppm to 44 ppm in the RB and CRP conditions respectively. Decreases were immediately evident in both conditions for all participants. The mean incorrect rates on the AS probes are also shown for each of the children in Table 8.14. Each child had a higher mean incorrect rate in the RB condition than in the CRP condition. The group mean incorrect rates for the AS probes were 4.6 (SD = 2.0) and 9.6 (SD = 1.3) for the RB and

Table 8.14: Mean correct and incorrect auditory stability rates for participants scoring within the poor reading range.

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Liam	65.6	63.2	26.3	28.2	4.0	3.8	6.1	7.6
Ryan	64.2	61.8	30.8	15.9	2.0	1.2	3.5	1.0
Troy	73.7	78.7	33.0	32.4	7.5	0.5	11.1	0.5
Wesley	99.7	81.1	36.2	33.1	4.7	2.3	9.9	2.9
Group	75.8	72.2	14.3	8.8	4.6*	9.6*	2.0	1.3

CRP conditions respectively. A significant difference was found between the students' mean incorrect rates in the two conditions ($T = 0$, $p < 0.05$).

The AS follow-up data indicated that each participant attained higher correct rates in the RB condition than in the CRP condition. The group mean correct rate was 104.7 (SD = 19.7) for the RB condition, which was much higher than the group mean for the CRP condition of 85.3 (SD = 13.1) and the difference was statistically significant ($T = 0$, $p < 0.05$). The incorrect rates on the AS follow-up probes were equal in each condition for two of the children and slightly higher in the CRP condition than in the RB condition for Troy. The group mean incorrect rates were 2 (SD = 2.2) and 2.7 (SD = 3.1) for the RB and CRP conditions respectively.

* statistically significant difference ($T = 0$, $p < 0.05$).

<u>Auditory stability rates for the participants scoring within the average reading range on the TERA-3.</u>

The correct and incorrect see/say rates on the AS probes for the children scoring within the average reading range on the TERA-3 are shown in Figures 13.45 to 13.48 (Appendix 11). Correct rates during the baseline phase ranged from 0 ppm to 16 ppm in the RB and CRP conditions on the AS probes. All participants showed increases in correct rates on these probes in both conditions over the intervention period. The participants' mean correct rates over the treatment phase are shown in Table 8.15. Each of the students had higher mean correct rates in the RB condition than in the CRP condition on the AS probes. A significant difference was found between the children's mean rates in the two conditions ($T = 0$, $p < 0.05$). The group mean correct rate for the AS probes of 73.5 (<u>SD</u> = 9.8) for the RB condition was higher than the group mean correct rate for the CRP condition, which was 66.7 (<u>SD</u> = 11.4).

The incorrect see/say rates on the baseline AS probes were initially high, ranging from 16 ppm to 54 ppm in the RB condition and from 14 ppm to 56 ppm in the CRP condition. Immediate decreases in incorrect rates were evident for most of the children in both conditions on the AS probes. Tahni initially showed an increase in incorrect rate in the RB condition on the first AS probe before her rates began to decline in this condition. The mean AS incorrect rates are shown in Table 8.15 for each participant. All of the children had higher incorrect rates in the RB condition than in the CRP condition for the AS probes. The group mean incorrect rate for the RB condition was 6.0 (<u>SD</u> = 3.1) compared to 2.3 (<u>SD</u> = 0.9) for the CRP condition. There was a significant difference between the participants' mean incorrect AS rates in the two conditions ($T = 0$, $p < 0.05$).

Table 8.15: Mean correct and incorrect auditory stability rates for participants scoring within the average reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Kyle	84.1	78.5	30.0	10.9	8.3	1.7	14.7	1.1
Lee	65.0	55.6	25.8	22.0	3.6	3.2	5.2	2.4
Lucy	82.3	77.7	25.1	9.0	2.3	3.0	3.1	2.2
Tahni	62.4	55.2	31.4	18.8	9.6	1.2	16.2	0.4
Group	73.5*	66.7*	9.8	11.4	6.0	2.3	3.1	0.9

Each of the children demonstrated higher correct rates on the AS follow-up probes in the RB condition than in the CRP condition. The group mean correct rate on the AS follow-up probes was 87 (SD = 6.1) in the RB condition compared to a group mean of 71 (SD = 14.9) in the CRP condition. The difference between groups was statistically significant ($T = 0$, $p < 0.05$). The group mean incorrect rates were 1.8 (SD = 0.4) and 4.8 (SD = 4.8) for the RB and CRP condition respectively. The difference was statistically significant ($T = 0$, $p < 0.05$).

Combined Auditory / Visual Stability rates

The CAVS probes involved a combined visual and auditory distraction in the form of a child's movie played with the sound and the picture. The CAVS probes were conducted during the baseline phase and during the intervention period after each participant had reached a specific rate aim in the RB condition or had completed an equal number of practice repetitions in the CRP condition.

CAVS rates for the participants scoring within the very poor reading range on the TERA-3.

Figures 13.49 to 13.52 (Appendix 11) show the correct and incorrect see/say rates on the CAVS probes for the children scoring within the very poor reading range on the TERA-3. Correct rates on the CAVS probes were very low during the baseline phase, ranging from 0 ppm to 1 ppm in the RB condition and from 0 ppm to 5 ppm in the CRP condition. Increases in correct rates on the CAVS probes were observed for each individual in both conditions over the intervention period. Sean demonstrated consistently higher correct rates in the RB condition for the entire treatment phase. James and Aaron initially demonstrated higher correct rates in the CRP condition on the first CAVS probes and Christopher initially showed a higher rate on the first two CAVS probes in the intervention phase. However, each of these participants performed at correct rates that were higher in the RB condition for the remainder of the CAVS probes over the period of intervention.

The mean correct see/say rates on the CAVS probes for each of the children are shown in Table 8.16. The participants each had higher mean correct rates on the CAVS probes in the RB condition than in the CRP condition. Moreover, the differences between

Table 8.16: Mean correct and incorrect combined auditory / visual stability rates for participants scoring within the very poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Aaron	72.5	56.3	31.4	21.9	6.3	3.8	10.3	4.8
Christopher	58.6	42.4	25.0	7.3	3.6	2.0	5.8	1.4
James	51.8	31.4	24.5	13.1	10.4	2.4	16.4	2.9
Sean	44.0	10.8	12.6	4.3	8.0	1.0	8.7	1.0
Group	56.7*	35.2*	10.5	16.7	7.1*	2.3*	2.5	1.2

the mean rates in the two conditions were noteworthy, ranging from 16.2 to 33.3. There was a significant difference between the students' correct rates in the two conditions ($T = 0$, $p < 0.05$). The group mean correct rates on the CAVS for the RB and CRP conditions were 56.7 (SD = 10.5) and 35.2 (SD = 16.7) respectively.

The incorrect rates on the CAVS baseline measures for the participants scoring within the very poor range on the TERA-3 ranged from 3 ppm to 50 ppm in the RB condition and from 3 ppm to 41 ppm in the CRP condition. Immediate decreases in incorrect rates were observed in both conditions for Aaron and Christopher. James and Sean demonstrated immediate decreases in incorrect rates in the CRP condition but initially showed increases in incorrect rates in the RB condition on the first CAVS probe. However,

* statistically significant difference ($T = 0$, $p < 0.05$).

declining trends in incorrect rate data were observed for these children over the remainder of the treatment period.

The mean incorrect rates for each of the children over the intervention phase are shown in Table 8.16. The students each had higher incorrect rates in the RB condition and there was a significant difference between the means in the two conditions ($T = 0$, $p < 0.05$). The group mean incorrect rate for the CAVS probes was higher in the RB condition at 7.1 (SD = 2.5) than in the CRP condition, for which the mean was 2.3 (SD = 1.0).

The CAVS follow-up data are shown in Figures 13.49 to 13.52 (Appendix 11). Each of the participants showed decreases in correct rates from the intervention phase to the follow-up phase, although both demonstrated some retention of correct rate on the CAVS follow-up probes. Aaron and James achieved higher correct rates in the RB condition than in the CRP condition on these tests. The group mean correct CAVS rates on the follow-up measures were 54.5 (SD = 12.5) and 49 (SD = 10) for the RB and CRP condition respectively. The difference between conditions was statistically significant ($T= 0$, $p < 0.05$). The incorrect rates had increased by the follow-up tests for both children and the group mean incorrect rates were 9.5 (SD = 0.5) and 9 (SD = 2) for the RB and CRP conditions correspondingly. The difference was not statistically significant ($T = 1$, $p > 0.05$).

CAVS rates for the participants scoring within the poor reading range on the TERA-3.

The baseline measures revealed that correct see/say rates on the CAVS were very low, ranging from 0 ppm to 4 ppm in both conditions for the participants scoring within the poor range on the TERA-3. Figures 13.53 to 13.56 (Appendix 11) show the correct and

Table 8.17: Mean correct and incorrect combined auditory / visual stability rates for participants scoring within the poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Liam	64.4	61.0	26.1	25.9	4.8	1.8	7.1	2.6
Ryan	61.6	58.6	33.2	12.0	2.6	0.8	3.8	0.8
Troy	72.8	79.2	33.7	33.6	8.8	1.7	12.4	1.5
Wesley	95.1	80.6	38.6	30.8	4.1	2.9	7.8	4.4
Group	73.5	69.8	13.2	10.1	5.1*	1.8*	2.3	0.7

incorrect rates on the CAVS for each of these participants. Increases in correct rates on the CAVS were evident for all children and in both conditions. The mean correct see/say rates on the CAVS for each of the participants are shown in Table 8.17. Three of the participants had higher mean correct rates in the RB condition than in the CRP condition, whilst the remaining child had a higher mean in the latter condition. There was no significant difference between the children's mean correct rates in the two conditions ($T = 3$, $p < 0.05$). The group mean correct rate of 73.5 (SD = 13.2) was higher in the RB condition than the group mean of 69.8 (SD = 10.1) for the CRP condition.

The incorrect see/say rates on the CAVS during the baseline phase ranged from 11 ppm to 47 ppm in the RB condition and from 13 ppm to 36 ppm in the CRP condition. Each of the children showed an immediate decrease in incorrect rates in both conditions

* statistically significant difference ($T = 0$, $p < 0.05$).

and there was a declining trend over the treatment period. The mean incorrect rates for each individual are also shown in Table 8.17. All participants had higher mean incorrect rates in the RB condition than in the CRP condition on the CAVS probes. There was a significant difference between the students' mean incorrect rates in the two conditions ($T = 0$, $p < 0.05$). The group mean incorrect rate was 5.1 (SD = 2.3) in the RB condition compared to only 1.8 (SD = 0.7) in the CRP condition.

The CAVS follow-up probes showed that two of the participants performed at correct rates that were higher in the RB condition than in the CRP condition and the remaining child had equal correct rates in the two conditions. The group mean correct rate on the CAVS follow-up probes for the RB condition was 97.7 (SD = 15.9) and for the CRP condition it was 83.3 (SD = 17.2). There was a statistically significant difference between conditions ($T = 0$, $p < 0.05$). The group mean incorrect rates were 2.7 (SD = 3.1) and 4 (SD = 2.9) for the RB and CRP condition correspondingly and the difference was statistically significant ($T = 0$, $p < 0.05$).

CAVS rates for the participants scoring within the average reading range on the TERA-3.

The participants' correct see/say rates on the baseline measures for the CAVS probes ranged from 0 ppm to 15 ppm in the RB condition and from 0 ppm to 12 ppm in the CRP condition. These are shown in Figures 13.57 to 13.60 in Appendix 11. Increases in correct rates were evident for each of the children in both conditions. The mean correct rates on the CAVS probes are shown for the RB and CRP conditions in Table 8.18. The RB mean correct rates were higher than the CRP mean rates for each child. There was a significant difference between the rates in the two conditions ($T = 0$, $p < 0.05$). The group

Table 18.18: Mean correct and incorrect combined auditory / visual stability rates for participants scoring within the average reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Kyle	79.5	73.7	33.8	11.4	7.0	2.2	14.8	2.0
Lee	76.5	75.8	25.4	14.9	3.8	1.7	3.1	2.1
Lucy	64.8	56.4	28.2	22.5	3.4	2.2	4.4	1.2
Tahni	61.6	55.6	36.4	17.7	3.6	1.0	5.3	0.9
Group	70.6*	65.4*	7.6	9.4	4.5*	1.8*	1.5	0.5

mean correct rates for the CAVS probes in the RB and CRP conditions were 70.6 (SD = 7.6) and 65.4 (SD = 9.4) respectively.

Incorrect see/say rates in the baseline phase on the CAVS probes ranged from 15 ppm to 53 ppm in the RB condition and from 17 ppm to 56 ppm in the CRP condition. Immediate decreases in incorrect rates were evident for all participants in both conditions and declining trends were observed over the intervention period. The mean incorrect rates for each of the children are shown in Table 18.18. Again all of the students had higher mean incorrect rates in the RB condition than in the CRP condition. There was a significant difference between the participants' rates in the two conditions ($T = 0$, $p < 0.05$). The group mean incorrect rate for the CAVS in the RB condition was 4.5 (SD = 1.5) whilst for the CRP condition the group mean was 1.8 (SD = 0.5).

* statistically significant difference ($T = 0$, $p < 0.05$).

The children each attained higher correct rates in the RB condition than in the CRP condition on the CAVS follow-up probes. The group mean correct rate was 79.3 (SD = 5.3) in the RB condition compared to only 63.3 (SD = 12.1). The difference was statistically significant ($T = 0$, $p < 0.05$). Most individuals demonstrated similar incorrect rates in the two conditions on the CAVS follow-up probes. However, Kyle showed a significantly higher incorrect rate in the CRP condition than in the RB condition. The group mean incorrect rates for the RB and CRP conditions were 2.3 (SD = 1.3) and 5.3 (SD = 5.7) respectively. There was not a statistically significant difference between conditions ($T = 1$, $p > 0.05$).

Application 1 rates

The Application 1 probes involved participants reading the individual phonemes within the context of pseudowords. Application 1 probes were conducted during the baseline phase and during the intervention phase after each child had reached a specific rate aim in the RB condition or had completed an equal number of practice repetitions in the CRP condition. Three months after the termination of the intervention the Application 1 probes were again conducted.

Application 1 rates for the participants scoring within the very poor reading range on the TERA-3.

The correct and incorrect rates on the Application 1 probes for each of the children scoring within the very poor range on the TERA-3 are shown in Figures 13.61 to 13.64 in Appendix 11. All participants demonstrated a 0 ppm correct rate in both conditions on the baseline Application 1 probes. Christopher achieved an increase in his correct rate on the Application 1 probes in both conditions by the timing for the first rate aim. However, the

Table 8.19: Mean correct and incorrect Application 1 rates for participants scoring within the very poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Aaron	32.7	23.3	29.2	28.6	6.3	14.0	7.1	3.7
Christopher	28.8	18.4	14.5	7.4	2.0	6.8	3.7	3.8
James	10.0	7.2	13.2	13.4	10.8	13.2	6.3	6.4
Sean	19.0	15.0	16.3	10.0	6.5	4.0	8.2	4.2
Group	22.6*	16.0*	8.8	5.9	6.4*	9.5*	3.1	4.2

remaining three children did not show immediate increases in correct rates in either condition. Aaron began to demonstrate increases in correct rate on the Application 1 probes in the CRP condition by the 42-62 ppm rate aim but it was not until he reached the following rate aim that he began to show increases in his RB correct rate. Alternatively, James showed an increase in his RB correct rate by the 42-62 ppm rate aim but did not demonstrate any increases in the CRP condition until the 84-104 ppm rate aim. Sean showed increases in correct rates in both conditions by the 42-62 ppm rate aim.

The mean correct see/say rates for each of the participants in both conditions for the Application 1 probes are shown in Table 8.19. Higher correct mean rates were evident in the RB condition than in the CRP condition for all of the participants. There was a significant difference between the participants' mean correct rates in the two conditions (T

* statistically significant difference ($T = 0$, $p < 0.05$).

= 0, $p < 0.05$). The group mean correct rate for the Application 1 probes was 22.6 (SD = 8.8) for the RB condition compared to only 16.0 (SD = 5.9).

The baseline measures indicated that incorrect rates on the Application 1 probes ranged from 20 ppm to 28 ppm in the RB condition and from 14 ppm to 32 ppm in the CRP condition. Data concerning incorrect rates were inconsistent across participants during the intervention period. Aaron showed a gradual decline in incorrect rate in the RB condition over the treatment phase on the Application 1 probes. Although his CRP incorrect rate data did show a slight declining trend, his incorrect rates remained relatively high in this condition over the period of intervention. Christopher demonstrated a rapid decrease in incorrect rates in the RB condition and these rates remained at zero levels after the 21-41 ppm rate aim timing. However, there was evidence of a very slight increasing trend in Christopher's incorrect rate data in the CRP condition and this rate remained relatively high over the intervention period. James had variable and high incorrect rates in both conditions over the treatment phase, until the 105-125 ppm rate aim when there was a sharp decline in his incorrect rates to 0 ppm and 4 ppm in the RB and CRP conditions respectively. Finally, Sean showed a more consistent decrease in incorrect rates in both conditions over the intervention phase.

The mean incorrect see/say rates for each of the participants are shown in Table 8.19. Three of the children had lower mean incorrect rates in the RB condition than in the CRP condition. The remaining participant had equal mean incorrect rates in both conditions. There was a significant difference between the children's mean rates in the two conditions ($T = 0$, $p < 0.05$). The group mean incorrect rate was lower in the RB condition at 6.4 (SD = 3.1) than in the CRP condition for which the group mean was 9.5 (SD = 4.2).

The Application 1 follow-up data are shown in Figures 13.61 to 13.64. Aaron and James demonstrated lower correct rates on the Application 1 follow-up probes than they demonstrated on the final timing in the intervention period. However, both children showed some retention on the follow-up Application 1 probes and each had higher correct rates in the RB condition than in the CRP condition. The group mean correct rates on the Application 1 probes were 45 (SD = 13) and 30 (SD = 10) for the RB and CRP conditions respectively and the difference was statistically significant ($T = 0$, $p < 0.05$). The group mean incorrect rates on the Application 1 follow-up probes were equal at 5 with standard deviations of 3 and 1 for the RB and CRP conditions correspondingly. There was no significant difference between the two conditions ($T = 1$, $p < 0.05$).

Application 1 rates for the participants scoring within the poor reading range on the TERA-3.

The correct and incorrect see/say rates on the Application 1 probes are shown in Figures 13.65 to 13.68 in Appendix 11 for students scoring within the poor range on the TERA-3. The baseline Application 1 probes showed that participants' correct rates were 0 ppm in both the RB and CRP conditions. Increases in correct rates on the Application 1 probes were evident for all children in both conditions over the treatment phase. Wesley showed a slight increase in correct rate in the RB condition on the timing for the first rate aim but this declined to 0 ppm by the following target training rate timing. His CRP rate remained at 0 ppm for both of these timings. At the 63-83 ppm rate aim Wesley showed marked increases in correct rates in both the RB and CRP conditions and this incline in data continued for the rest of the intervention period. Troy demonstrated similar and steady increases in correct rates in both conditions over the treatment period. Ryan's correct rates

.20: Mean correct and incorrect Application 1 rates for participants scoring within the poor reading range

cipant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
	34.8	29.6	21.4	21.4	5.2	11.2	6.5	6.5
	21.2	27.2	16.1	14.7	8.8	4.0	5.7	7.0
	48.0	50.0	27.6	27.8	5.7	1.7	6.5	1.3
	60.0	60.6	47.5	48.8	7.7	7.1	10.9	8.3
	41.0	41.8	15.5	14.0	6.9	6.0	1.5	3.6

ed at 0 ppm in both conditions until the 42-62 ppm rate aim timing at which point ʼas a very rapid increase in correct rate in the CRP condition and a less sharp, but ɔnounced, increase in the RB condition. Liam showed a slight increase in correct the CRP condition at the first rate aim. Although he did not show any increase on ing for the first rate aim in the RB condition, his correct rate in this condition was ently higher or equal to the rates in the CRP condition for all successive rate aims.

The mean correct rates on the Application 1 probes are shown in Table 8.20 for articipant. One child had a higher mean correct rate in the RB condition than in the ondition. The three remaining students had higher mean correct rates in the latter ıon. The differences between the means in the two conditions ranged from 0.6 to 6. was no significant difference between the rates in the two conditions (T = 3, p >

0.05). The group mean correct rates were very similar at 41 (SD = 14.5) for the RB condition and 41.8 (SD = 14.0) for the CRP condition.

The incorrect see/say rates ranged from 20 ppm to 22 ppm in the RB condition and from 8 ppm to 20 ppm in the CRP condition on the Application 1 baseline measures. Decreasing trends in incorrect data on the Application 1 probes were evident for all participants in both conditions over the period of intervention. The mean incorrect rates on the Application 1 probes are shown for each participant in Table 8.20. Three of the children had higher mean incorrect rates in the RB condition than in the CRP condition. The remaining participant had a higher mean incorrect rate in the latter condition. Differences between the means in the two conditions ranged from 0.6 to 6 and no significant difference was found ($T = 4$, $p > 0.05$). The group mean incorrect rate was slightly higher in the RB condition at 6.9 (SD = 1.5) than in the CRP condition for which it was 6 (SD = 3.6).

The Application 1 follow-up probes showed that one of the children attained a higher correct rate in the RB condition, whilst the remaining two individuals achieved higher rates in the CRP condition. The group mean correct rate for the Application 1 follow-up probes in the RB condition was 80.7 (SD = 19.8) for the RB condition. The group mean was higher in the CRP condition at 86 (SD = 17.3). There was no statistically significant difference between the two conditions ($T = 1.5$, $p > 0.05$). There was little difference between the participants' incorrect rates in the two conditions on the follow-up probes, although two children demonstrated slightly higher incorrect rates in the RB condition and the remaining child showed a higher incorrect rate in the CRP condition. The group mean incorrect rates for the RB and the CRP conditions on the Application 2 follow-up tests were 2 (SD = 1.6) and 0.7 (SD = 0.9) and the difference was not statistically significant ($T = 1.5$, $p > 0.05$).

Application 1 rates for the participants scoring within the average reading range on the TERA-3.

Correct and incorrect rates on the Application 1 probes for the participants scoring within the average range on the TERA-3 are shown in Figures 13.69 to 13.72. All of the children had 0 ppm correct rates in both conditions on the Application 1 baseline probes. Increasing trends in correct rate data were evident for all participants in both conditions over the intervention period on the Application 1 probes. Lucy did not show an increase in her correct rate in the RB condition until the 42-62 rate aim although each of the other participants showed immediate increases in correct rate in this condition. Kyle did not demonstrate increases in his CRP correct rate until the 42-62 ppm rate aim although each of the other children showed immediate increases in this condition.

The mean correct rates for each participant are shown in Table 8.21. One child had a higher mean correct rate in the RB condition than in the CRP condition whilst the remaining three children had higher mean correct rates in the CRP condition. Differences between the mean correct rates in the two conditions ranged from 0.8 to 18. There was no significant difference between the mean correct rates in the two conditions ($T = 2$, $p > 0.05$). The group mean correct rate was higher for the CRP condition at 49.7 (SD = 9.6) than for the RB condition for which it was 43.6 (SD = 9.4).

The participants' incorrect rates ranged from 12 pm to 38 ppm in the RB condition and from 10 ppm to 32 ppm in the CRP condition on the baseline Application 1 measures. There were decreasing trends in each of the children's incorrect rate data in both conditions

Table 8.21: Mean correct and incorrect Application 1 rates for participants scoring within the average reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Kyle	34.8	41.5	17.0	27.4	9.3	12.0	8.8	15.4
Lee	59.3	58.0	33.7	20.2	9.3	4.0	10.0	3.3
Lucy	42.4	60.4	26.2	28.2	5.2	0.8	6.1	1.0
Tahni	38.0	38.8	23.1	16.9	2.4	2.8	4.8	2.7
Group	43.6	49.7	9.5	9.6	6.6	4.9	2.9	4.3

over the intervention period. Lee and Tahni demonstrated increases in incorrect rates on the timing for the first rate aim in the RB condition before their rates began to decline. Alternatively, Kyle initially demonstrated an increase in incorrect rate in the CRP condition before his incorrect rate began to decline in this condition.

The mean incorrect rates are shown in Table 8.21 for each participant. Two of the students had higher mean incorrect rates in the RB condition, whilst the remaining two children had higher mean incorrect rates in the CRP condition. There was no significant difference found between the mean incorrect rates in the two conditions ($T = 3$, $p > 0.05$). The group mean incorrect rates for the RB and CRP conditions were 6.6 (SD = 3.0) and 4.9 (SD = 4.3) respectively.

The Application 1 follow-up probes showed that each of the children attained higher correct rates in the RB condition than in the CRP condition. Lee demonstrated a dramatically higher correct rate in the former condition. The group mean correct rate on the Application 1 probes in the RB condition was 86 (SD = 12.81) compared to a group mean rate of only 68.5 (SD = 21.6) in the CRP condition and the difference was statistically significant between conditions ($T = 0$, $p < 0.05$). Three of the children demonstrated higher incorrect rates in the CRP condition than in the RB condition whilst Taylor showed similar rates in the two conditions. The group mean incorrect rate for the Application 1 probes was 2 (SD = 3.5) in the RB condition and in the CRP condition it was 2.5 (SD = 3.3) and the difference was not statistically significant ($T = 2.5$, $p > 0.05$).

Application 2 rates

The Application 2 probes involved the participants orally blending the digraphs and phonemes to read the pseudowords.

Application 2 rates for the participants scoring within the very poor reading range on the TERA-3.

The correct and incorrect rates on the Application 2 probes are shown in Figures 13.73 to 13.76 in Appendix 11. Baseline Application 2 correct rates were 0 ppm in the RB condition for each participant and ranged from 0 ppm to 2 ppm in the CRP condition. The results varied across participants over the intervention period. Aaron showed immediate increases in correct rate on the Application 2 probes in the RB condition in the intervention phase and increasing trends in data were evident over this period. Christopher showed immediate increases in correct rate in the CRP condition but did not demonstrate increases in the RB condition until the 42-62 ppm rate aim. James began to demonstrate

Table 8.22: Mean correct and incorrect Application 2 rates for participants scoring within the very poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Aaron	51.7	44.3	38.8	25.5	7.0	19.3	7.6	5.7
Christopher	32.0	30.8	20.8	11.1	4.0	4.0	5.5	2.3
James	8.4	2.8	5.1	5.6	17.6	14.0	9.8	4.6
Sean	1.0	0	1.7	0	4.5	5.0	0.9	1.0
Group	22.4*	19.5*	20.0	18.7	8.3	10.6	5.5	6.4

improvements in his correct rate at the 42-62 rate aim in the RB condition but it was not until the 105-125 ppm rate aim that he showed any increase in his correct rate in the CRP condition. Sean demonstrated improvements in his RB correct rate only at the 84-104 ppm rate aim. His CRP rate never increased beyond 0 ppm for the entire intervention period.

The mean correct rates on the Application 2 probes for each of the participants are shown in Table 8.22. The children had higher mean correct rates in the RB condition than in the CRP condition and a significant difference was found between conditions ($T = 0$, $p < 0.05$). The differences between the correct means in the two conditions ranged from 1 to 7.3. The group mean correct rate was 22.4 (SD = 20) for the RB condition and 19.5 (SD = 18.7) for the CRP condition.

* statistically significant difference ($T = 0$, $p < 0.05$).

The incorrect rates on the Application 2 baseline measures ranged from 6 ppm to 24 ppm in the RB condition and from 6 ppm to 22 ppm in the CRP condition. Aaron's incorrect rate declined gradually over the intervention period in the RB condition. His CRP incorrect rate was more variable and remained at consistently higher levels than in the RB condition. Christopher's RB incorrect rate remained the same as at baseline after reaching the first rate aim but subsequently showed a consistent decline. His CRP incorrect rate decreased initially but began to rise on the final two timings of the intervention period. High variability was observed in James' incorrect rates in both conditions. He demonstrated very high incorrect rates on some timings, particularly in the RB condition. However, declining trends in the data were found. Sean's incorrect rates were also variable in the two conditions and did not show any significant decreases over the intervention period.

The mean incorrect rates for each of the participants are shown in Table 8.22. Two children had higher mean incorrect rates in the CRP condition, one had a higher mean incorrect rate in the RB condition and for one individual the means were the same in the two conditions. The differences between the rates in the two conditions ranged from 0 to 12.3. There was no significant difference found between the mean incorrect rates in the two conditions ($T = 0$, $p > 0.05$). The group mean incorrect rate for the Application 2 probes was lower in the RB condition at 8.3 ($\underline{SD} = 5.5$) than in the CRP condition for which the mean group incorrect rate was 10.6 ($SD = 6.4$).

The follow-up Application 2 probes indicated that correct rates in both conditions had decreased from the final timing in the intervention phase to the follow-up phase for Aaron. Although James' correct rates also decreased in the RB condition from the intervention phase to the follow-up phase, his correct rates actually increased from the final timing in the intervention phase in the CRP condition. Aaron achieved a higher correct rate in the RB condition whilst James attained a higher correct rate in the CRP condition on the follow-up probes. The group mean correct rate for the Application 2 follow-up probes was 42 (SD = 28) for the RB condition and for the CRP condition it was lower at 37 (SD = 21) and the difference was not statistically significant ($T = 1, p > 0.05$). The participants' incorrect rates were lower on the follow-up probes in both conditions than on the final timing in the intervention phase. One child had a lower incorrect rate in the RB condition whilst the other demonstrated a lower incorrect rate in the CRP condition. The group mean incorrect rates on the Application 2 follow-up probes for the RB and CRP conditions were 4 (SD = 4) and 7 (SD = 3) and the difference was not statistically significant ($T = 1, p > 0.05$).

Application 2 rates for the participants scoring within the poor reading range on the TERA-3.

Figures 13.77 to 13.80 in Appendix 11 show the correct and incorrect rates on the Application 2 probes for the children scoring within the poor range on the TERA-3. Their rates ranged from 0 ppm to 8 ppm in the RB condition and from 0 ppm to 6 ppm in the CRP condition on the Application 2 baseline measures. Increases in correct rates on the Application 2 probes were observed for each of the children over the period of intervention.

The mean correct see/say rates on the Application 2 probes are shown in Table 8.23. Two of the participants had higher correct rates in the RB condition whilst the remaining two participants had higher rates in the CRP condition. The differences between the two conditions ranged from 0.4 to 8.3 and there was no significant difference found between the

Table 8.23: Mean correct and incorrect Application 2 rates for participants scoring within the poor reading range

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Liam	42.8	42.0	23.7	15.8	7.2	7.6	4.8	6.6
Ryan	26.0	26.4	16.2	13.5	7.6	9.6	4.3	3.9
Troy	61.7	50.3	34.3	38.9	4.7	8.7	4.7	6.2
Wesley	78.3	84.3	48.2	45.7	4.9	4.6	6.4	6.9
Group	52.2	50.8	19.7	21.2	6.1	7.6	1.3	1.9

means in the two conditions ($T = 5$, $p > 0.05$). The group mean correct rate of 52.2 (SD = 19.7) was higher for the RB condition than for the CRP condition for which it was 50.8 (SD = 21.2).

The mean incorrect rates on the baseline Application 2 probes ranged from 14 ppm to 20 ppm in the RB condition and from 14 ppm to 30 ppm in the CRP condition. All participants demonstrated decreases in incorrect rates in both conditions during the intervention period, although Ryan's data showed more variability than for the other participants. The mean incorrect rates for each of the participants on the Application 2 probes are shown in Table 8.23. Three of the children had lower incorrect rates in the RB condition than in the CRP condition and the remaining child had a lower incorrect rate in the CRP condition. Differences between the means in the two conditions ranged from 0.4

to 2.3. The group mean incorrect rate was higher in the CRP condition and was 7.6 (SD = 1.9). The group mean incorrect rate was 6.1 (SD = 1.3) in the RB condition. There was not a statistically significant difference between conditions ($T = 1$, $p > 0.05$).

The Application 2 follow-up data indicated that one participant attained a higher correct rate in the RB condition, one child achieved a higher rate in the CRP condition and for the remaining individual the correct rates in the two conditions were equal. The group mean correct rate on the Application 2 follow-up probes was higher in the CRP condition at 111.3 (SD = 11.1) than in the RB condition for which the group mean was 109. (SD = 29.3). There was not a statistically significant difference between conditions ($T = 1$, $p > 0.05$). The incorrect rates in the two conditions were 0 ppm for all of the participants.

Application 2 rates for the participants scoring within the average reading range on the TERA-3.

The correct and incorrect rates on the Application 2 probes for the participants scoring within the average reading range on the TERA-3 are shown in Figures 13.81 to 13.84 in Appendix 11. The baseline correct rates ranged from 0 ppm to 8 ppm in both conditions. Increases in correct rates on the Application 2 probes were evident for each of the participants over the period of intervention. More rapid increases in correct rates were initially observed in the CRP condition for Kyle and Tahni. At the 63-83 ppm rate aim timing Tahni's correct rate in the RB condition surpassed her CRP rate and remained higher in the former condition for the remainder of the intervention period. Also at the 62-83 ppm rate aim timing, Kyle's RB rate was almost at his CRP rate levels, although variability in both conditions was evident in the timings that followed. Lee's RB correct

Table 8.24: Mean correct and incorrect Application 2 rates for participants scoring within the average reading range.

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Kyle	94.7	117	42.6	27.5	11.7	4.3	16.8	5.5
Lee	72.7	63.3	25.5	27.7	11.7	11.7	9.4	5.8
Lucy	46.4	69.8	32.2	35.1	6.4	3.6	7.8	3.4
Tahni	42.4	38.0	26.9	23.2	2.0	1.6	3.1	1.5
Group	64.0	72.0	21.2	28.6	7.9*	5.3*	4.1	3.8

rate remained higher than his CRP rate for most of the intervention. Conversely, Lucy's CRP correct rate was consistently higher than her RB rate over the treatment period.

The mean correct rates are shown for each child in Table 8.24. Lee and Tahni had higher mean correct rates in the RB condition than in the CRP condition whilst Lucy and Kyle had higher mean rates in the latter condition. The differences between the means in the two conditions ranged from 4.4 to 23.4. There was no significant difference between the participants' mean rates in the two conditions ($T = 1$, $p > 0.05$). The group mean correct rate for the Application 2 probes was higher in the CRP condition ($M = 72.0$; $SD = 28.6$) than in the RB condition ($M = 64.0$; $SD = 21.2$).The incorrect see/say rates on the Application 2 baseline probes ranged from 16 ppm to 50 ppm in the RB condition and from 16 ppm to 42 ppm in the CRP condition. Decreases in incorrect rates on the Application 2

* statistically significant difference ($T = 0$, $p < 0.05$).

probes were demonstrated by each of the participants in both conditions over the intervention phase. Most of the participants showed decreases in incorrect rates to zero and near zero levels over the intervention period, although Lee's incorrect rates remained higher than the other participant's rates over the treatment phase. Three of the children's incorrect rates on the Application 2 probes were higher in the RB condition than in the CRP condition, with differences between the means ranging from 0.4 to 7.3. Lee had the same mean incorrect rates in the two conditions. There was a significant difference found between the students' mean rates in the two conditions ($T = 0$, $p < 0.05$). The group mean incorrect rate of 7.9 (SD = 4.1) for the RB condition was higher than the group mean for the CRP condition of 5.3 (SD = 3.8).

The Application 2 follow-up probes showed that three of the participants performed correct rates that were higher in the RB condition than in the CRP condition. Lee demonstrated a higher correct rate in the latter condition. The group mean correct rate was 94.5 (SD = 24.5) for the RB condition and 92.5 (SD = 25.9) in the CRP condition on the Application 2 follow-up probes and the difference was not statistically significant ($T = 3$, $p > 0.05$). The incorrect rates were higher in the CRP condition for two children, in the RB condition for one child and were the same in the two conditions for the remaining individual on the follow-up probes. The group mean incorrect rates for the RB and CRP conditions were 2.8 (SD = 3.3) and 5 (SD = 5) respectively and the difference was statistically non-significant ($T = 1.5$, $p > 0.05$).

Adduction 1 rates

The Adduction 1 tests involved the participants using letter names to orally spell the pseudowords as they were read to the children. The probes were conducted during the baseline phase and repeated measures were conducted throughout the intervention phase. Three months after the intervention was completed the follow-up probes were administered.

Adduction 1 rates for the participants scoring within the very poor range on the TERA-3.

The correct and incorrect rates on the Adduction 1 probes are shown in Figures 13.85 to 13.88 in Appendix 11 for the participants scoring within the very poor range on the TERA-3. All of the children had baseline correct rates of 0 ppm in both conditions on the Adduction 1 probes.

Sean did not show any increases in correct rates in either the RB or CRP conditions over the intervention period and his rates remained at 0 ppm. James did not demonstrate any increases in correct rate in the CRP condition until the 105-125 ppm rate aim at which point his rate increases very slightly to 2 ppm. Conversely, he did show increases in correct rate on the Adduction 1 probes over the intervention phase in the RB condition after the 21-41 ppm rate aim, although these rates remained very low with the highest being only 8 ppm. Christopher demonstrated consistently higher correct rates in the RB condition than in the CRP condition for the majority of Adduction 1 probes in the intervention phase. His correct rate in the CRP condition initially increased but began to decline after the 63-83 ppm rate aim before leveling for the final two rate aims in the intervention phase. Aaron demonstrated much higher correct rates on the Adduction 1 probes than the other participants. His CRP rate was consistently higher than his RB rate on the probes until after the 105-125 ppm rate aim when the data intercepted and his RB rate exceeded his CRP rate.

Table 8.25: Mean correct and incorrect Adduction 1 rates for participants scoring within the very poor reading range.

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Aaron	12.3	15.7	14.8	11.2	11.7	8.3	4.7	2.7
Christopher	8.4	4.8	5.7	3.2	4.8	3.6	1.9	1.8
James	3.6	0.4	2.7	0.8	10.4	12.4	3.4	2.3
Sean	0	0	0	0	8	7.5	3.2	2.2
Group	6.1	5.2	4.7	6.3	8.7	8.0	2.6	3.1

The mean correct rates for each of the participants on the Adduction 1 probes are shown in Table 8.25. The mean rates were very low for each of the children for the Adduction 1 probes. Christopher and James each had higher mean correct rates in the RB condition than in the CRP condition whilst Aaron had a higher mean correct rate in the latter condition. Sean had mean correct rates of 0 ppm in both conditions. The group mean correct rate of 6.1 (SD = 4.7) in the RB condition was slightly higher than the group mean of 5.2 (SD = 6.3) in the CRP condition. There was no significant difference between the participants' correct rates in the two conditions ($T = 2$, $p > 0.05$).

Incorrect rates ranged from 2 ppm to 12 ppm in the RB condition and from 4 ppm to 12 ppm in the CRP condition on the baseline Adduction 1 probes. Sean's incorrect rates remained at similar levels in both conditions over the intervention period and showed a very slight increasing trend. However, there was very little change to his incorrect rates over the treatment phase. James' incorrect rates on the Adduction 1 probes increased for a number of rate aim timings in the intervention phase in both conditions. At the 84-104 ppm rate aim his RB incorrect rate declined and then showed a rapid decrease at the next rate aim. His CRP incorrect rates showed a slight decrease at the 105-125 ppm rate aim. Christopher's incorrect rates were variable in the two conditions but the data indicated slight downward trends. Aaron's incorrect rates remained higher in the RB condition than in the CRP condition for most of the rate aim timings in the intervention phase. His RB incorrect rate did show a rapid decrease at the 126-146 ppm rate aim at which point it became lower than his incorrect rate in the CRP condition.

The mean incorrect rates for each of the participants are shown in Table 8.25. Three participants had higher mean incorrect rates in the RB condition than in the CRP condition whilst James had a higher mean rate in the latter condition. The group mean incorrect rate was 8.7 ($\underline{SD}$ = 2.6) for the RB condition and 8.0 ($\underline{SD}$ = 3.1) for the CRP condition. There was no significant difference between the incorrect rates in the two conditions ($T = 3$, $p > 0.05$).

The follow-up Adduction 1 probes indicated that Aaron and James' correct rates had decreased from the final timing in the intervention phase. James did not show any retention of correct rate on the Adduction 1 follow-probes in the CRP condition but did show some retention in the RB condition on these probes. Aaron demonstrated some retention in both conditions on the follow-up Adduction 1 probes and had a higher correct rate in the CRP condition than in the RB condition. The group mean correct rate for the RB condition was 8 ($\underline{SD}$ = 6) and for the CRP condition it was 12 ($\underline{SD}$ = 12) on the follow-up Adduction 1 probes and the difference was not statistically significant between conditions ($T = 1$, $p > 0.05$). The group mean incorrect rates were 9 (SD = 1) and 11 (SD = 5) for the RB and CRP conditions respectively and the difference was statistically non-significant $T = 1$, $p < 0.05$).

Adduction 1 rates for the participants scoring within the poor range on the TERA-3.

Figures 13.89 to 13.92 in Appendix 11 show the correct and incorrect rates on the Adduction 1 probes for the participants scoring within the poor range on the TERA-3. The children each demonstrated correct rates of 0 ppm on the baseline Adduction 1 probes. Each participant showed relatively similar correct rates in the two conditions over the period of intervention and these rates remained low.

The mean correct rates for each of the students are shown in Table 8.26. The mean rates were very low for each of the participants. Three of the children had higher mean correct rates in the RB condition than in the CRP condition on the Adduction 1 probes. Conversely, Wesley had a higher mean rate in the CRP condition. The differences between the mean correct rates in the two conditions were relatively small, ranging from 0.8 to 2.7. The group mean correct rates for the Adduction 1 probes were 6.1 (SD = 2.6) and 5.4 (SD = 4.0) for the RB and CRP condition respectively. There was no significant difference between the two conditions ($T = 3$, $p > 0.05$).

The baseline incorrect rates on the Adduction 1 probes ranged from 4 ppm to 8 ppm in the RB condition and from 2 ppm to 10 ppm in the CRP condition for each of the participants scoring within the poor range on the TERA-3. The incorrect rates remained at

Table 8.26: Mean correct and incorrect Adduction 1 rates for participants scoring within the poor reading range.

Participant	**Mean Correct Rate**		**SD**		**Mean Incorrect Rate**		**SD**	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Liam	4.8	4.0	4.8	2.8	8.0	6.8	4.2	3.7
Ryan	3.2	2.4	2.4	2.0	7.2	7.6	1.6	2.0
Troy	5.7	3.0	2.9	2.2	8.7	12.3	1.9	4.4
Wesley	10.6	12.3	7.7	6.7	8.3	6.9	2.0	2.6
Group	6.1	5.4	2.6	4.0	8.1	8.4	0.5	2.3

similar levels during the intervention period to those recorded in the baseline phase for each of the participants.

The mean incorrect rates for each child on the Adduction 1 probes are shown in Table 8.26. Two individuals had higher mean incorrect rates in the RB condition, whilst the remaining two participants had higher mean rates in the CRP condition. The group mean incorrect rates were 8.1 (SD = 0.5) and 8.4 (SD = 2.3) for the RB and CRP conditions correspondingly. There were no significant differences between the children's incorrect rates in the two conditions ($T = 5$, $p > 0.05$).

The Adduction 1 follow-up probes revealed that each of the participants had maintained their correct rates in both conditions from the intervention phase to the follow-up phase. Moreover, all participants showed an increase in correct rates on the follow-up tests from the intervention phase. There was one child who attained a higher correct rate in the RB condition, one who performed at a higher rate in the CRP condition and one child who achieved the same correct rates in the two conditions on the follow-up probes. The group mean correct rate on the Adduction 1 follow-up probes was 19.3 for the RB and CRP conditions with standard deviations of 6.2 and 6.6 correspondingly and the difference was not statistically significant ($T = 1$, $p > 0.05$). The group mean incorrect rates were 5.3 (SD = 0.9) and 4 (SD = 2.8) for the RB and CRP conditions and the difference was statistically non-significant ($T = 1$, $p > 0.05$).

Adduction 1 rates for the participants scoring within the average range on the TERA-3.

The correct and incorrect rates on the Adduction 1 probes are shown in Figures 13.93 to 13.96 for each of the participants who scored within the average range on the TERA-3. The correct rates were 0 ppm in the RB and the CRP conditions for all participants during the baseline phase.

The participants each demonstrated increases in correct rates on the Adduction 1 probes in both conditions over the intervention phase. Lee showed consistently higher correct rates in the RB condition than in the CRP condition on the probes. Tahni also demonstrated higher rates in the RB condition on most of the probes. Lucy showed higher correct rates in the CRP condition for most of the intervention period until the 105-125 ppm rate aim when she performed at a slightly higher rate in the RB condition. Kyle initially demonstrated higher correct rates in the RB condition for a number of rate aim timings until the 84-104 ppm rate aim at which point his CRP exceeded his RB rate and remained higher for each successive timing in the intervention period.

Table 8.27: Mean correct and incorrect Adduction 1 rates for participants scoring within the average reading range.

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Kyle	24.0	25.7	13.5	19.7	3.0	5.3	3.0	4.4
Lee	28.7	16.7	13.8	17.9	3.0	13.7	4.3	3.5
Lucy	5.6	9.6	4.8	4.3	10.4	6.4	3.9	2.3
Tahni	8.8	6.0	4.5	5.5	1.6	5.2	1.5	1.0
Group	16.8	14.5	9.8	7.5	4.5	7.7	3.5	3.5

The mean correct rates in the RB and CRP conditions for each of the children who scored within the average range on the TERA-3 are shown in Table 8.27. Two participants had higher mean correct rates in the RB condition whilst the remaining two had higher mean rates in the CRP condition. The group mean correct rate for the Adduction 1 probes was higher in the RB condition at 16.8 (SD = 9.8) than in the CRP condition for which the mean was 14.5 (SD = 7.5). There was no significant difference between the participants' mean correct rates in the two conditions ($T = 5$, $p > 0.05$).

The incorrect rates on the baseline Adduction 1 measures ranged from 6 ppm to 10 ppm in the RB condition and from 4 ppm to 8 ppm in the CRP condition. Kyle, Lee and Tahni generally demonstrated lower incorrect rates on the rate aim timings in the RB condition than in the CRP condition over the intervention phase. Lucy's incorrect rates in he RB condition were commonly equal to or slightly above her incorrect rates in the CRP condition over the treatment phase.

The mean incorrect rates on the Adduction 1 probes for each of the participants are shown in Table 8.27. Three children had mean incorrect rates that were lower in the RB condition whilst Lucy had a lower mean incorrect rate in the CRP condition. The group mean incorrect rate was 4.5 (SD = 3.5) for the RB condition, which was lower than the CRP group mean of 7.7 (SD = 3.5). There was no significant difference between the mean incorrect rates in the two conditions ($T = 3$, $p > 0.05$).

The Adduction 1 follow-up probes showed that two of the children achieved higher correct rates in the RB condition than in the CRP condition, whilst two attained higher rates in the latter condition. Lucy showed a particularly large difference in performance in the two conditions. The group mean correct rate for the Adduction 1 follow-up probes was 26 (SD = 17.0) for the RB condition and 21 (SD = 15.3) for the CRP condition and the difference was statistically non-significant ($T = 4.5$, $p > 0.05$). The group mean incorrect rates for the Adduction 1 follow-up probes for the RB and CRP conditions were 6 (SD = 5.1) and 5 (SD = 2.2) respectively and the difference was statistically non-significant ($T = 3.5$, $p > 0.05$).

Adduction 2 rates

The Adduction 2 probes were tests that required the participants to circle the correct phonemes in the appropriate order on worksheets in order to spell the pseudowords.

Adduction 2 rates for the participants scoring within the very poor range on the TERA-3.

The correct and incorrect rates for each of the children scoring within the very poor range on the TERA-3 are shown in Figures 13.97 to 13.100. The baseline correct rates on the Adduction 2 probes ranged from 0 ppm to 2 ppm in the RB condition and from 0 ppm to 12 ppm in the CRP condition.

The participants each demonstrated increases in correct rates on the Adduction 2 probes. Sean showed only very small increases in correct rates in the two conditions over the intervention period and these rates were similar in each condition. James' data showed variability in the two conditions although increases in correct rates were evident in the two conditions. Christopher initially demonstrated higher correct rates in the CRP condition on the Adduction 2 probes. However, at the 63-83 ppm rate aim, his RB rate surpassed his CRP rate and remained higher for the remainder of the intervention phase. Aaron generally demonstrated higher correct rates on the probes in the RB than in the CRP condition over the intervention period.

The mean correct rates for each of the children scoring within the very poor range on the TERA-3 for the Adduction 2 probes are shown in Table 8.28. Two children had higher mean correct rates in the RB condition than in the CRP condition and for the other two participants the reverse was observed. The group mean correct rates were very similar at 10.4 ($\underline{SD}$ = 4.0) for the RB condition and 10.1 ($\underline{SD}$ = 4.0) for the CRP condition. There was no significant difference between the students' mean correct rates in the two conditions ($T = 5$, $p > 0.05$).

Table 8.28: Mean correct and incorrect Adduction 2 rates for participants scoring within the very poor reading range.

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Aaron	14.0	12.0	8.6	8.1	5.3	6.7	3.2	5.0
Christopher	14.4	15.2	6.6	3.56	0.8	0.8	1.5	0.9
James	8.0	8.8	5.9	4.8	4.8	4.0	1.0	2.2
Sean	5.0	4.5	2.2	2.2	2.5	5.0	0.9	2.2
Group	10.4	10.1	4.0	4.0	3.4	4.1	1.8	2.1

The participants' mean incorrect rates ranged from 6 ppm to 10 ppm in the RB condition and from 6 ppm to 12 ppm in the CRP condition. Each of the children showed decreases in incorrect rates in both conditions over the intervention phase. The mean incorrect rates for each of the participants in both conditions are shown in Table 8.28. Two individuals had lower mean incorrect rates in the RB condition than in the CRP condition. James had a slightly lower mean rate in the CRP condition, whilst Christopher had equal means in the two conditions. The group mean incorrect rate was slightly lower in the RB condition at 3.4 (SD = 1.8) than in the CRP condition for which the mean incorrect rate was 4.1 (SD = 2.1). There was no significant difference between the mean incorrect rates in the two conditions ($T = 1$, $p > 0.05$).

The Adduction 2 follow-up data are shown in Figures 13.95 to 13.98 in Appendix 11. The data showed decreases in correct rates for both participants from the intervention phase to the follow-up probes, although retention was in evidence for both of the children. Aaron attained a higher correct rate in the RB condition whilst James achieved a higher correct rate in the CRP condition on the follow-up Adduction 2 tests. The group mean correct rate for the RB condition was 16 (SD = 6) and the CRP group mean was 17 (SD = 3) and the difference was statistically non-significant ($T = 1$, $p < 0.05$). Aaron had 0 ppm incorrect rates on the follow-up probes whilst James showed a decrease in his CRP incorrect rate from the intervention phase and an increase in his RB incorrect rate. The group mean incorrect rate for the Application 2 follow-up tests in the RB condition was 3 (SD = 3) and for the CRP condition it was 2 (SD = 2) and the difference was statistically non-significant ($T = 1$, $p < 0.05$).

Adduction 2 rates for the participants scoring within the poor range on the TERA-3.

Figures 13.101 to 13.104 show the correct and incorrect rate data on the Adduction 2 probes for each of the children scoring within the poor range on the TERA-3. The baseline correct rates on the Adduction 2 probes ranged from 0 ppm to 4 ppm in the RB condition and from 0 ppm to 8 ppm in the CRP condition. The correct rate data followed similar increasing trends in the two conditions for each of the participants over the period of intervention.

The mean correct rates for each child in the RB and CRP conditions are shown in Table 8.29. There was generally little difference between the mean rates in the two conditions. Two participants had mean correct rates that were higher in the RB condition.

Table 8.29: Mean correct and incorrect Adduction 2 rates for participants scoring within the poor reading range.

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	CRP	RB	CRP	RB	CRP	RB	CRP
Liam	15.6	15.6	3.2	4.1	2.4	2.0	2.8	1.3
Ryan	10.4	10.8	4.5	2.0	3.6	2.8	0.8	1.0
Troy	22.0	15.7	11.3	5.6	2.7	1.7	0.9	1.4
Wesley	18.9	18.4	7.2	7.3	0.3	0.6	0.7	1.4
Group	16.7	15.1	14.3	2.8	2.3	1.8	1.3	1.3

Ryan had a very slightly higher mean rate in the CRP condition whilst for Liam his mean correct rates were equal in the two conditions. The group mean correct rate was 16.7 (SD = 14.3) in the RB condition, which was slightly higher than the group mean of 15.1 (SD = 2.8) in the CRP condition. There was no significant difference between the rates in the two conditions ($T = 1$, $p > 0.05$).

The incorrect rates on the baseline Adduction 2 probes ranged from 2 ppm to 10 ppm in the RB condition and from 2 ppm to 6 ppm in the CRP condition. There was again very little difference between the RB and CRP incorrect rate data. Each participant showed decreases in incorrect rates in both conditions over the intervention period. The group mean incorrect rates were 2.3 (SD = 1.3) and 1.8 (SD = 1.3) for the RB and CRP conditions respectively. There was no significant difference between the mean rates in the two conditions ($T = 1$, $p > 0.05$).

The Adduction 2 follow-up probes showed that most of the students had maintained their correct rates in both conditions. Only Liam showed a very slight decrease in correct rate in the CRP condition from the intervention phase to the follow-up phase. The group mean correct rate for the follow-up Adduction 2 probes was 22.7 (SD = 4.1) in the RB condition and 21.3 (SD = 4.1) in the CRP condition and the difference was statistically non-significant ($T = 1$, $p > 0.05$). The mean group incorrect rates on the follow-up probes was 0.3 (SD = 0.9) for the RB and CRP conditions. The difference between conditions was statistically non-significant.

Adduction 2 rates for the participants scoring within the average range on the TERA-3.

The correct and incorrect rates on the Adduction 2 probes are shown in Figures 13.105 to 13.108 in Appendix 11 for the participants scoring within the average range on the TERA-3. The baseline correct rates on the probes ranged from 4 ppm to 8 ppm in the RB condition and from 6 ppm to 16 ppm in the CRP condition.

Increases in correct rates were observed for each child over the intervention phase. Kyle initially demonstrated more rapid increases in correct rate in the CRP condition on the timings for the first two rate aims. However, the correct rates in the two conditions followed similar trends after this timing. The correct rate data for each of the remaining participants showed similar trends across the intervention phase in the two conditions.

The mean correct rates are shown in Table 8.30 for each participant in both conditions. Lucy had equal mean correct rates on the Adduction 2 probes in the RB and

Table 8.30: Mean correct and incorrect Adduction 2 rates for participants scoring within the average reading range.

Participant	Mean Correct Rate		SD		Mean Incorrect Rate		SD	
	RB	**CRP**	**RB**	**CRP**	**RB**	**CRP**	**RB**	**CRP**
Kyle	23.0	24.7	7.9	3.4	1.0	0.3	1.5	0.8
Lee	22.7	22.0	5.9	5.9	0	1.0	0	2.2
Lucy	16.0	16.0	4.4	2.2	0.8	1.2	1.0	1.6
Tahni	15.6	18.0	6.3	2.8	3.2	1.6	2.8	2.0
Group	19.3	20.2	3.5	3.4	1.3	1.0	1.2	0.5

CRP conditions. Kyle had a very slightly higher mean rate in the CRP condition whilst the remaining two children had slightly higher mean correct rates in the RB condition on the Adduction 2 probes. The group mean correct rates for the two conditions were 19.3 (SD = 3.5) and 20.2 (SD = 3.4) for the RB and CRP rates respectively. There was no significant difference between the mean correct rates in the two conditions ($T = 1$, $p > 0.05$).

The incorrect rates on the baseline Adduction 2 probes ranged from 2 ppm to 6 ppm in the RB condition and from 2 ppm to 4 ppm in the CRP condition. The incorrect rates decreased on the Adduction 2 probes over the intervention phase for each of the participants. The mean incorrect rates are shown in Table 8.30. Two of the children had higher mean incorrect rates in the CRP condition and two had higher mean rates in the RB condition. The group mean incorrect rate in the RB condition was slightly higher than the mean in the CRP conditions. The group incorrect means were 1.3 (SD = 1.2) and 1.0 (SD = 0.5) for the RB and CRP conditions respectively and the difference was statistically non-significant ($T = 4$, $p > 0.05$).

The Adduction 2 follow-up probes indicated that Kyle achieved a higher correct rate in the RB condition, Lee and Tahni attained very slightly higher correct rates in the CRP condition and Lucy demonstrated similar rates in the two conditions. The group mean correct rates for the Adduction 2 follow-up probes were 23 (SD = 4.6) and 23 (SD = 3) in the RB and CRP conditions and the difference was statistically non-significant ($T = 3$, $p > 0.05$). The group mean incorrect rate on the follow-up probes for the RB and CRP conditions was 0.5 (SD = 0.7) and the difference was statistically non-significant ($T = 1$, $p > 0.05$).

Comparisons of RB see/say rates and RESAA rates

The correct see/say training rates for the RB condition at each rate aim over the intervention phase were included in each of the figures showing the children's rates on the RESAA measures that were described in the previous section (Figures 13.1 to 13.106 in Appendix 11). In the previous section, RESAA rates in the RB condition were compared to RESAA rates in the CRP condition. In this section, RESAA rates in the RB condition are compared to see/say training rates in the RB condition.

Comparisons of retention rates and RB training rates

The correct rates on the retention probes were lower than the see/say training rates over the entire period of intervention for three of the children who scored within the very poor TERA-3 range. Aaron initially demonstrated similar retention rates to his see/say training rates until the 63-83 ppm rate aim (Figure 13.1, Appendix 11). After this rate aim Aaron's correct see/say training rates increased much more rapidly than his retention rates and his see/say training rates remained higher for the rest of the intervention phase.

The four participants in the poor TERA-3 range each demonstrated retention rates that were similar to their see/say training rates over the intervention phase (Figures 13.5 to 13.8, Appendix 11). Ryan and Thomas' see/say training rates were very slightly higher than their retention rates at each rate aim. Wesley and Liam showed retention rates that were higher than their see/say training rates at some rate aims.

The children who scored within the average range on the TERA-3 also demonstrated similar retention and see/say training rates over the intervention phase (Figures 13.9 to 13.12, Appendix 11). Lee showed consistently higher retention rates than his see/say training rates until the 84-104 ppm rate aim. After this aim his see/say training rates increased more rapidly than his retention rates. Kyle, Lucy and Taylor performed at rates that were higher on some retention probes than on see/say training rate timings at some timings.

Comparisons of endurance rates and see/say training rates

The endurance rates at each rate aim were consistently lower than the see/say training rates over the intervention phase for the children scoring within the very poor range on the TERA-3 (Figures 13.13 to 13.16, Appendix 11). Aaron's endurance rates remained only slightly lower than his see/say training rates at each rate aim. However, the endurance rate and see/say training rate data for Sean and Christopher showed gradual divergence over the period of intervention. After the 84-104 ppm rate aim, James' endurance rates showed a rapid increase but did not reach his see/say training rates.

The endurance rates for Liam, Ryan and Troy, who scored within the poor range on the TERA-3, were consistently lower than their see/say training rates over the treatment phase, although the two types of data followed the same trends for each child (Figures 13.17 to 13.19 in Appendix 11). Wesley demonstrated similar see/say training rates and endurance rates until the 84-104 ppm rate aim (Figure 13.20 in Appendix 11). After this aim, his see/say training rates increased more rapidly than his endurance rates for the remaining rate aims.

The four children who scored within the average TERA-3 range demonstrated equal or lower endurance rates than see/say training rates at each rate aim (Figures 13.21 to 13.24 in Appendix 11). There was little difference between the see/say training rates and endurance rates for Lucy, Kyle and Lee throughout the intervention phase. Tahni's see/say training rate and endurance rate data showed a gradual divergence over the treatment phase.

Comparisons of stability rates and see/say training rates

Visual stability

Adam, who scored within the very poor TERA-3 range, showed very similar see/say training rates and VS rates at each rate aim (Figure 13.25 in Appendix 11). Christopher demonstrated similar see/say training rates and VS rates until the 84-104 ppm rate after which his see/say training rate increased more rapidly than his VS rate (Figure 13.26). James' see/say training rates remained consistently lower than his VS rates at each rate aim (Figure 13.27). Sean's VS rates also remained lower than his see/say training rates until the 63-83 ppm rate aim at which point his VS rate almost reached his see/say training rate (Figure 13.28). However, at the following rate aim his see/say training rate increased more rapidly than his VS rate.

Similar see/say training rates and VS rates were demonstrated by each of the children scoring within the poor TERA-3 range (Figures 13.29 to 13.32 in Appendix 11). Wesley attained higher rates on the VS probes than on the see/say training rate timings for most rate aims. The other three children attained higher see/say training rates than VS rates at most rate aims, although for Troy there was very little difference between the see/say training rates and VS rates.

Three of the participants who scored within the average TERA-3 range showed very similar see/say training rates and VS rates at each rate aim over the intervention phase (Figures 13.33, 13.35 and 13.36 in Appendix 11). Lee attained consistently higher VS rates than see/say training rates until the 63-83 ppm rate aim, after which his see/say training rate increased more rapidly (Figure 13.34 in Appendix 11). However, Lee's VS rate showed a rapid increase between the 84-104 ppm and 105-125 ppm rate aims, exceeding his see/say training rate on the final probe in the intervention period.

Auditory Stability

Aaron and James, who scored within the very poor TERA-3 range, demonstrated consistently lower AS rates than see/say training rates over the intervention period, although the two forms of data followed similar trends in each case (Figures 13.37 and 13.39 in Appendix 11). Sean's AS rate reached his see/say training rate at the 63-83 ppm rate, but his see/say training rate increased more rapidly on the next rate aim timings (Figure 13.40). Christopher demonstrated slightly lower AS rates than see/say training rates for most rate aims in the treatment period (Figure 13.38).

Most of the participants scoring within the poor TERA-3 range demonstrated similar see/say training rates and AS rates over the intervention period (Figures 13.41 to

13.44 in Appendix 11). Wesley, however, showed significantly higher AS rates than see/say training rates at the 42-62 ppm, 63-83 ppm and 84-104 ppm rate aims. After these aims his see/say training rates and AS rates were equal for the remaining rate aims in the intervention period.

Kyle, who scored within the average TERA-3 range, initially showed higher AS rates than see/say training rates until the 84-104 ppm rate aim at which point his see/say rates exceeded his AS rates (Figure 13.45 in Appendix 11). However, at the final rate aim (126-146 ppm) Kyle's see/say training rates and AS rates were equal. Very similar trends in data to Kyle's data were observed for Lee (Figure 13.46). Lucy had very similar see/say training rates and AS rates until the 63-83 ppm rate aim (Figure 13.47). After this aim the data showed divergence and her see/say training rates increased more rapidly than her AS rates. Tahni's AS rates were initially lower than her see/say training rates but the former had reached the training rate levels by the 84-104 ppm rate aim (Figure 13.48).

Combined auditory and visual stability

There were little differences in the CAVS rates and see/say training rates for Aaron and Christopher over the intervention period, although the CAVS rates were generally lower than the training see/say rates (Figures 13.49 and 13.50 in Appendix 11). At the 84-104 ppm rate aim Christopher's see/say training rate and CAVS rate data showed a sudden divergence as his see/say rate increased more rapidly than his CAVS rate. At the 126-146 ppm rate aim Aaron's CAVS rate increased rapidly and almost reached his see/say training rate. James' CAVS rates were consistently lower than his see/say training rates at each rate aim (Figure 13.51). At the 105-125 ppm rate aim his CAVS rate showed a rapid increase but did not reach his see/say training rate. Sean had a higher CAVS rate than see/say rate at the 42-62 ppm rate aim but the two forms of data showed divergence after this rate aim and his see/say training rates were consistently higher than his CAVS rates (Figure 13.52).

Wesley, who scored within the poor TERA-3 range showed higher CAVS rates than see/say training rates for most of the intervention phase, although after the 84-104 ppm rate aim the two rates were very similar on each successive probe (Figure 13.56 in Appendix 11). Troy and Liam generally had lower CAVS rates than see/say training rates at each rate aim in the treatment period but there were little differences between the two rates (Figures 13.55 and 13.53). Ryan demonstrated lower CAVS rates than see/say training rates until the 84-104 ppm rate aim timing, at which point his CAVS rates exceeded training rate levels (Figure 13.54). However, his see/say training rate surpassed his CAVS rate on the probe for the following rate aim.

The children who scored within the average range on the TERA-3 demonstrated very similar CAVS and see/say training rates over the intervention phase (Figures 13.57 to 13.60 in Appendix 11). After the 21-41 ppm rate aim Tahni's see/say training rates and CAVS rates were almost equal on each of the successive probes in the treatment period. Each of the other participants sometimes showed higher CAVS rates than see/say training rates, and vice versa, and there were very little differences between the two rates.

Comparisons of application rates and see/say training rates

Application 1

Figures 13.61 to 13.64 in Appendix 11 show the Application 1 and see/say training rate data for the children scoring within the very poor TERA-3 range. These figures show that there were very large differences between the see/say training rates and Application 1 rates. For each child the see/say training rates were much higher than the Application 1 rates at all rate aims in the intervention period. Aaron and Christopher showed gradual increases in Application 1 rates over the intervention period. James demonstrated a sudden rapid increase in Application 1 rate at the 84-104 ppm rate aim but this rate remained very much lower than his see/say training rate.

The Application 1 and see/say training rate data for the children scoring within the poor range on the TERA-3 rate show in Figures 13.65 to 13.68 (Appendix 11). Wesley initially demonstrated much higher see/say training rates than Application 1 rates. However, at the 105-125 ppm rate aim his Application 1 rate increased rapidly towards his see/say training rate. Although Wesley's Application 1 rate did not reach the levels of his see/say training rate, the difference between the two rates was much smaller at each successive rate aim than it had been on previous probes. The other three participants showed gradual increases in Application 1 rates but these rates remained well below their see/say training rates over the intervention period.

The children who scored within the average TERA-3 range also demonstrated lower Application 1 rates than see/say training rates at most rate aims in the intervention phase. These data are shown in Figures 13.69 to 13.72 (Appendix 11). Lee showed rapid increases in Application 1 rates from the 21-41 ppm to the 63-83 ppm rate aims. At the 63-83 ppm rate aim his Application 1 rate very slightly exceeded his see/say training rate but then remained lower than his see/say rate on each successive probe in the intervention phase. The other three children consistently demonstrated higher see/say training rates than Application 1 rates over the intervention period.

Application 2

Each of the children who scored within the very poor range on the TERA-3 demonstrated consistently lower Application 2 rates than see/say training rates over the intervention phase. These data are shown in Figures 13.73 to 13.76 in Appendix 11. Aaron showed a very dramatic increase in the Application 2 rate at the 105-125 ppm rate aim but this rate did not reach the levels of his see/say training rate.

The Application 2 and see/say training rate data for the children scoring in the poor range on the TERA-3 are shown in Figures 13.77 to 13.80 in Appendix 11. The participants generally demonstrated lower Application 2 rates than see/say training rates over the intervention period. Liam's Application 2 rate was very similar to his see/say training rate at the 63-83 ppm rate aim but remained lower than his see/say training rate for the remainder of the rate aims in the treatment period. Troy showed a rapid increase in Application 2 rate at the 105-125 ppm rate aim, although this rate did not reach his see/say training rate at this rate aim. Wesley also showed a rapid increase in Application 2 rate at the 105-125 ppm rate aim and did surpass his see/say training rate at this aim. His Application 2 rate remained higher than his see/say training rate on the following probe but was slightly below his see/say training rate by the probe that followed. Ryan demonstrated much lower Application 2 rates than see-say training rates over the intervention period.

Two of the children scoring within the average range on the TERA-3 showed higher Application 2 rates than see/say training rates on many of the probes in the intervention period. Lucy and Tahni demonstrated consistently lower Application 2 rates than see/say training rates at each rate aim. Kyle showed very rapid increases in Application 2 rate on the 63-83 ppm rate aim probe and surpassed his see/say training rate. His Application 2 rate remained higher for the following two rate aims before falling very slightly below his see/say training rate on the final probe in the intervention phase. Lee demonstrated a rapid increase in Application2 rate at the 42-62 ppm rate aim and this remained higher than his see/say training rate on the following probe. Some variability was evident on each successive Application 2 probe.

Comparisons of adduction rates and see/say training rates

Adduction 1

There were very large differences between the Adduction 1 rates and see/say training rates for the participants scoring within the very poor range on the TERA-3. Figures 13.85 to 13.88 in Appendix 11 show these data. Each of the children demonstrated consistently lower Adduction 1 rates than see/say training rates at each rate in the intervention phase. Aaron showed a spontaneous increase in Adduction 1 rate at the 126-146 ppm rate aim but this rate still remained much lower than his see/say training rate.

There were also very large differences between the Adduction 1 and see/say training rates for the children scoring within the poor range on the TERA-3. These data are shown in Figures 13.89 to 13.92 (Appendix 11). The Adduction 2 rates were much lower than the see/say training rates at each rate aim in the treatment period for this group of children. Liam showed a spontaneous rapid increase in Adduction 1 rate at the 105-125 ppm rate aim but this rate was well below his see/say training rate at the same rate aim.

The Adduction 1 and see/say training rate data for the children scoring within the average range on the TERA-3 are shown in Figures 13.93 to 13.96 in Appendix 11. These participants also showed large differences between Adduction 1 rates and see/say training ates over the intervention phase. The Adduction 1 rates were consistently lower than the see/say training rates for the children at each rate aim.

Adduction 2

All of the children in each TERA-3 range demonstrated consistently lower Adduction 2 rates than see/say training rates at each rate aim in the intervention phase. These data are shown in Figures 13.97 to 13.108 in Appendix 11. Moreover, the differences between the rates at each rate aim were large.

Group comparisons of RB see/say training rates and RESAA rates

In this section, mean group see/say training rates in the RB condition for the children in the three TERA-3 ranges are compared to one another at each rate aim. The mean group RESAA rates in the RB condition for the children in the three TERA-3 ranges are also compared to one another at each rate aim. These are shown in Figures 8.13 to 8.22. There are only five data points in each data series in these figures. This is because all participants in each TERA-3 range reached the fifth rate aim of 84-104 ppm. Therefore, each data point represents the mean of four scores. Only some children reached higher rate aims. Therefore, any data points beyond the 84-104 ppm rate aim would represent means of different quantities of scores and would be inconsistent.

Group see/say training rates

The mean see/say training rates for each TERA-3 group at each rate aim are shown in Figure 8.13. These rates were very similar for the three TERA-3 groups at each successive rate aim. Each group demonstrated consistent increases in correct see/say training rates in the RB condition. At the 63-83 ppm rate aim, the very poor and poor TERA-3 group

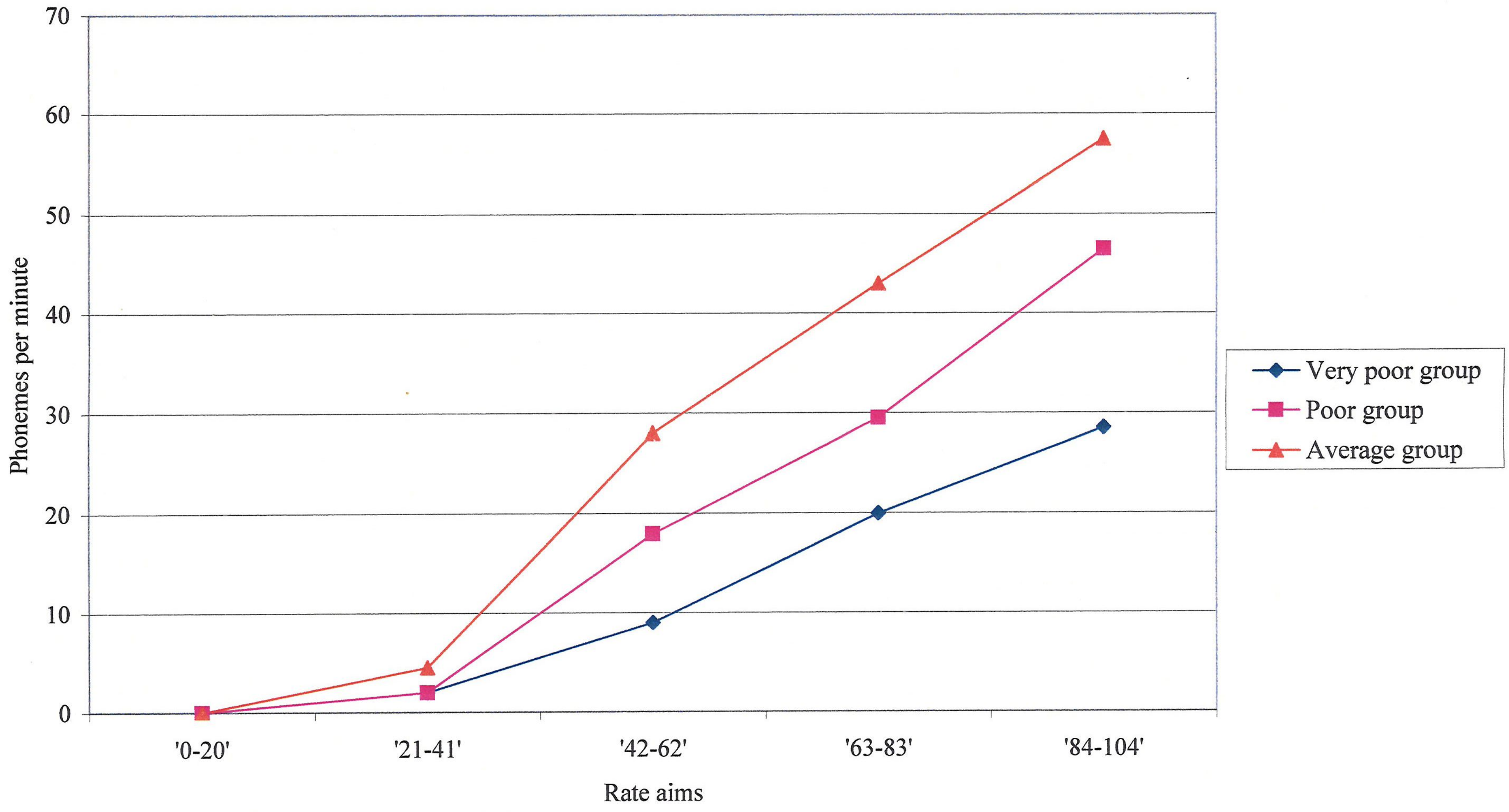

Figure 8.19: Mean correct Application 1 rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

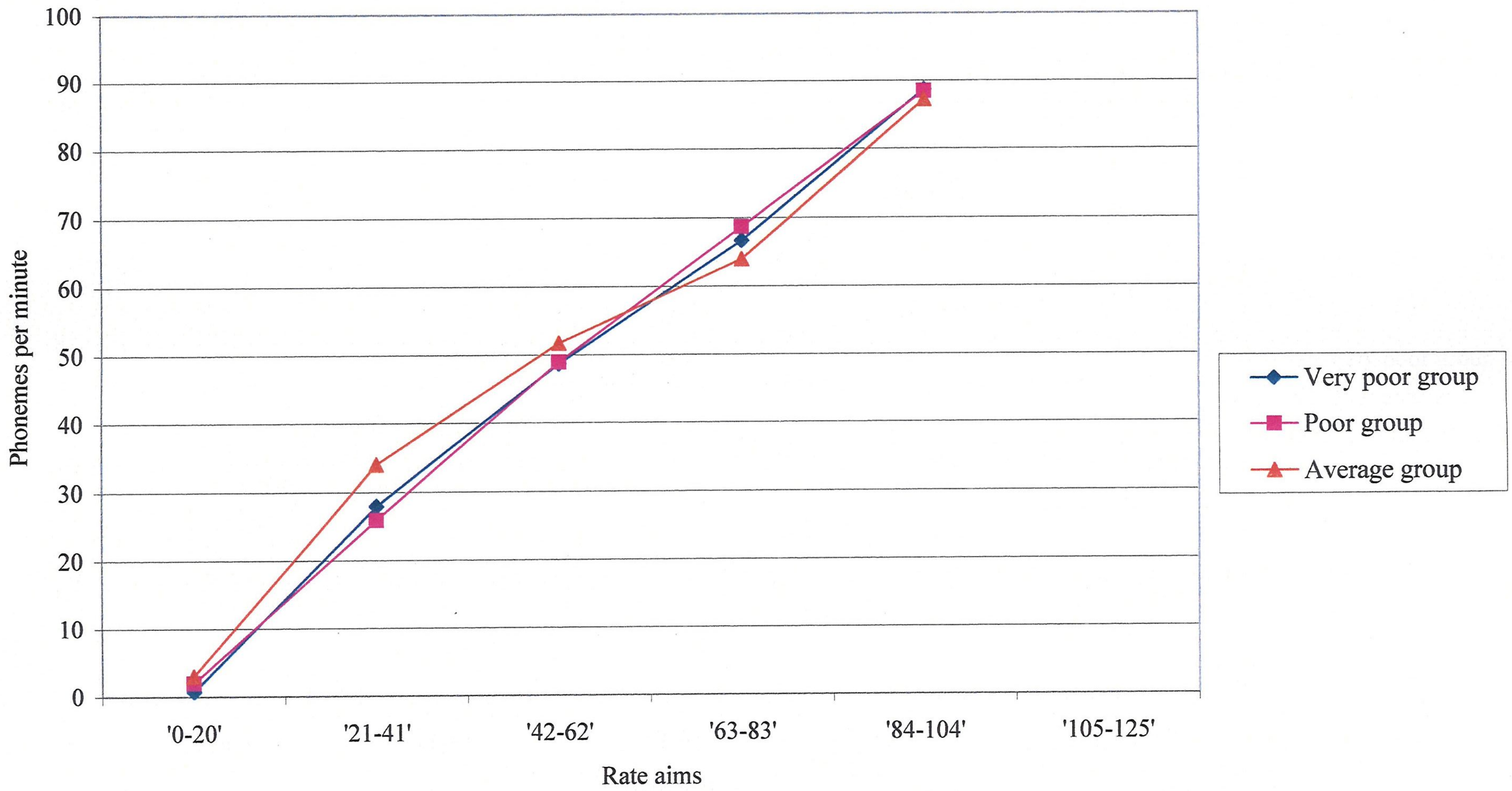

Figure 8.13: Mean correct see/say training rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

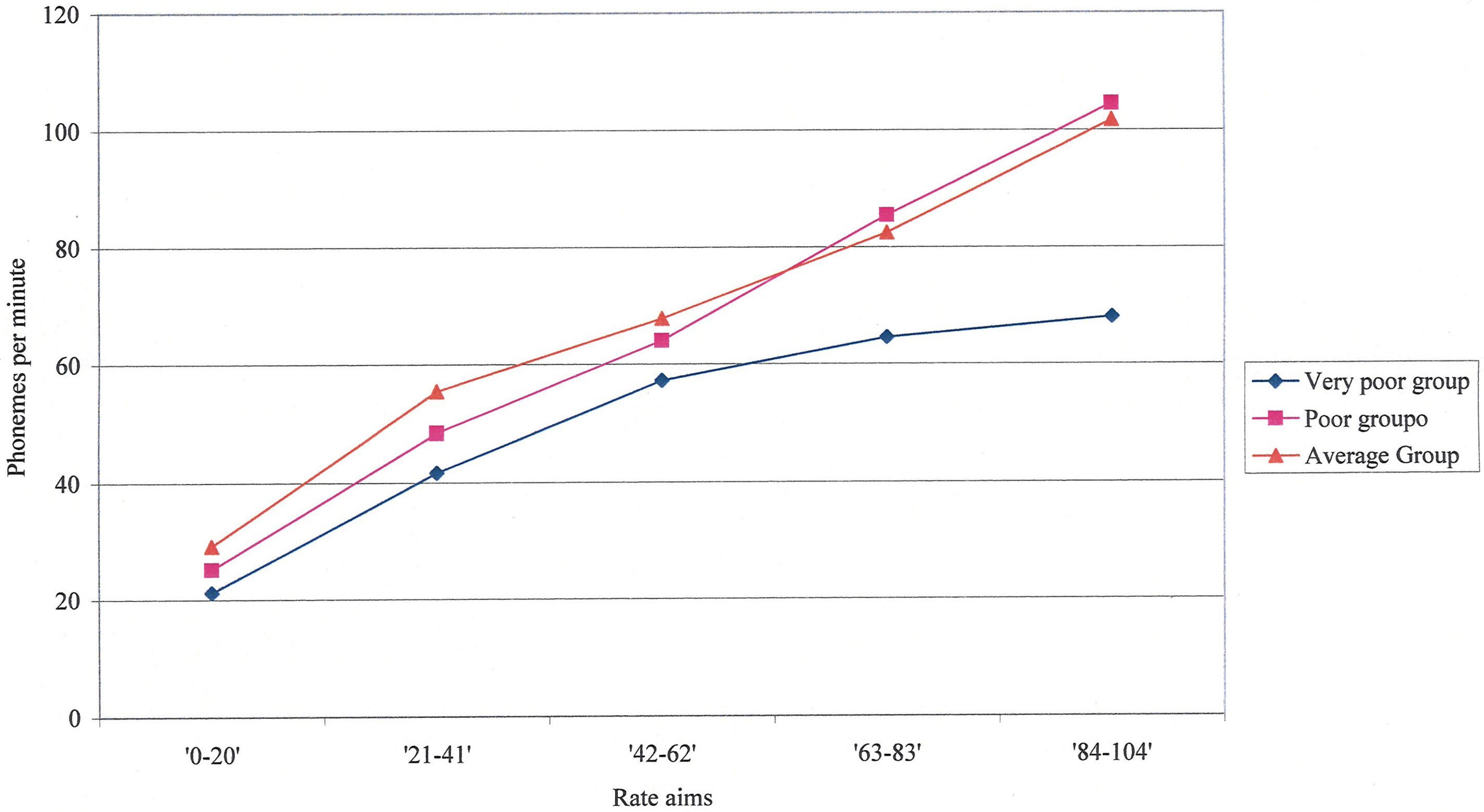

Figure 8.14: Mean correct retention rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

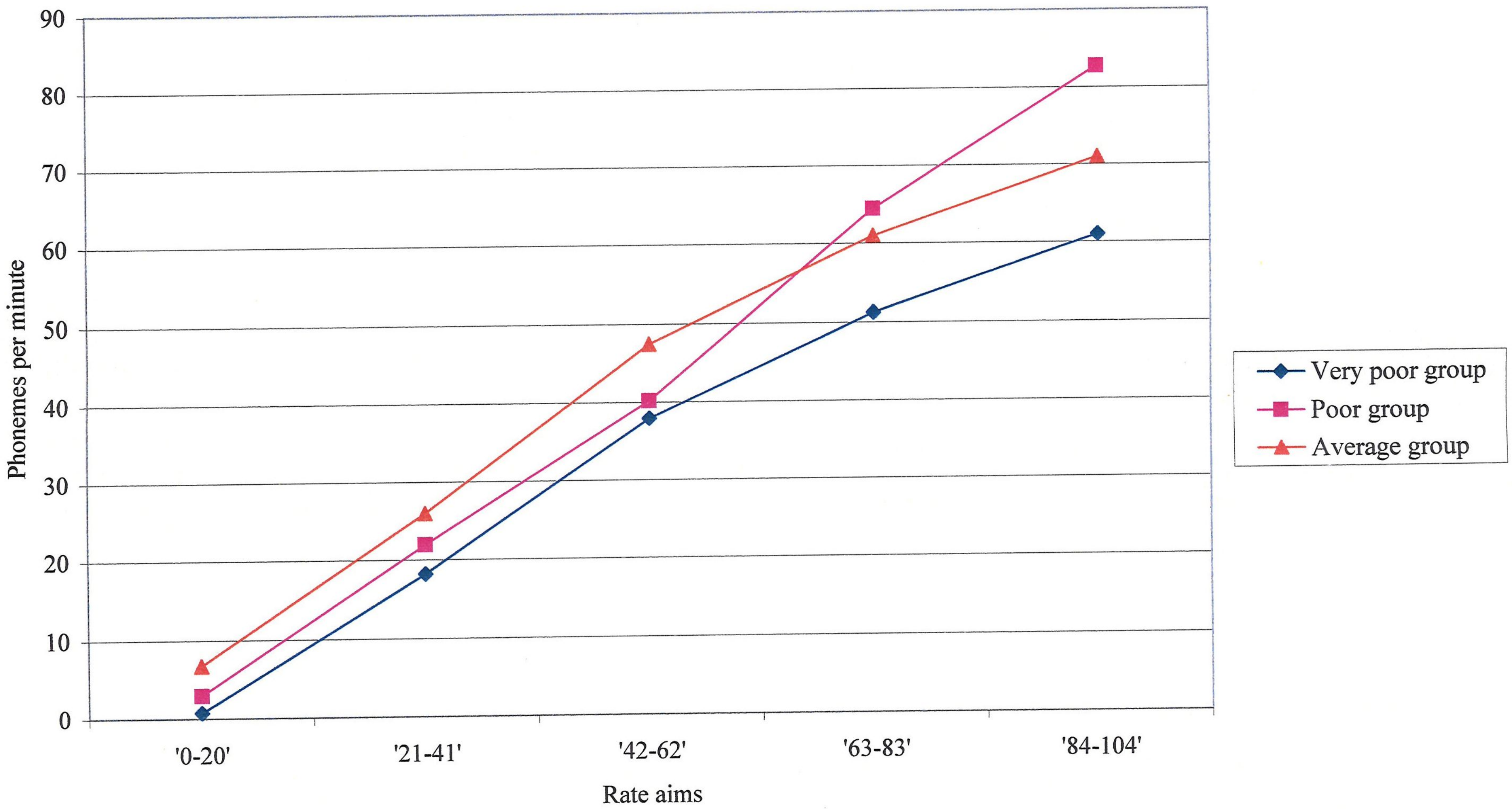

Figure 8.15: Mean correct endurance rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

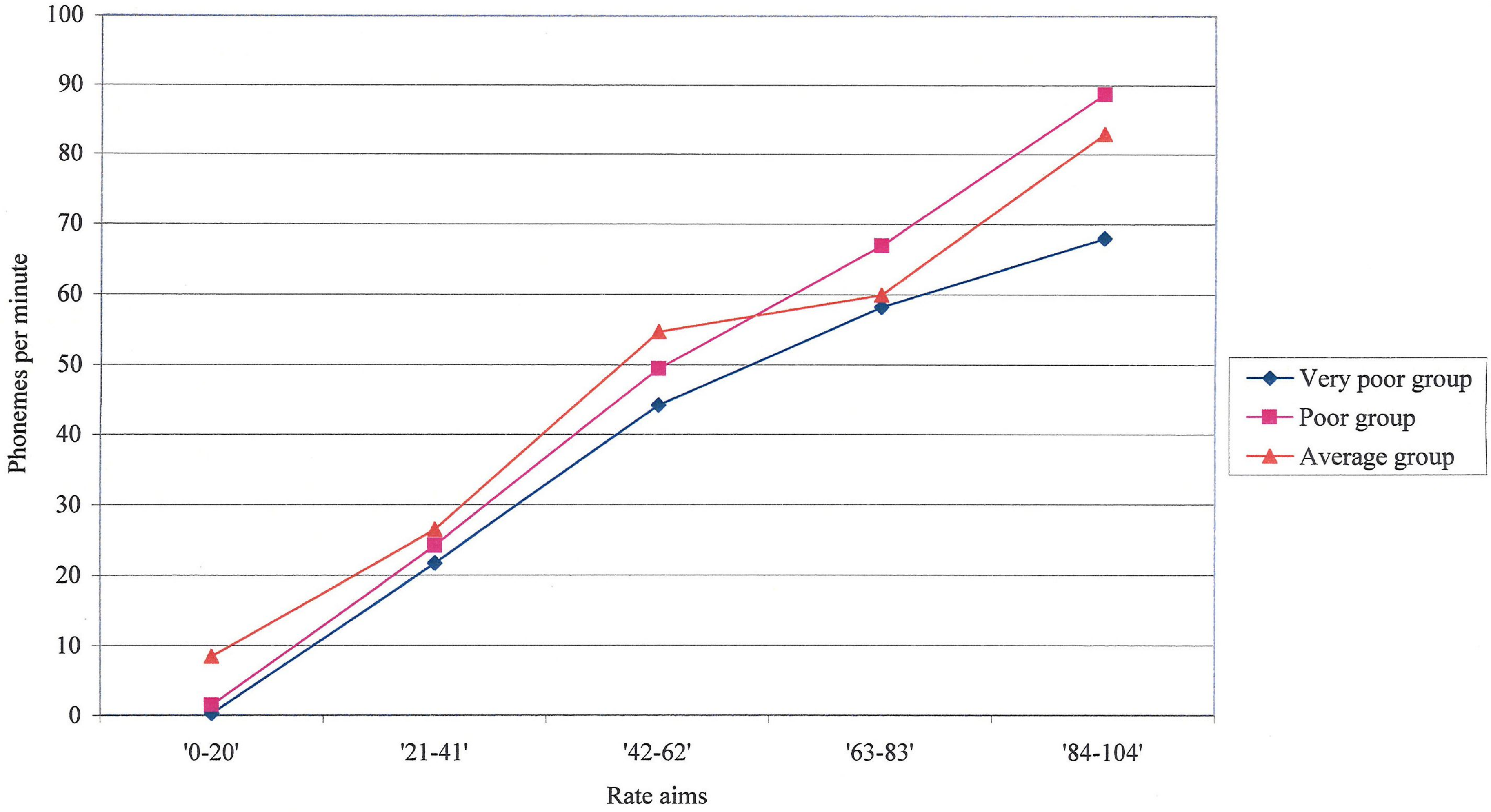

Figure 8.18: Mean correct CAVS rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

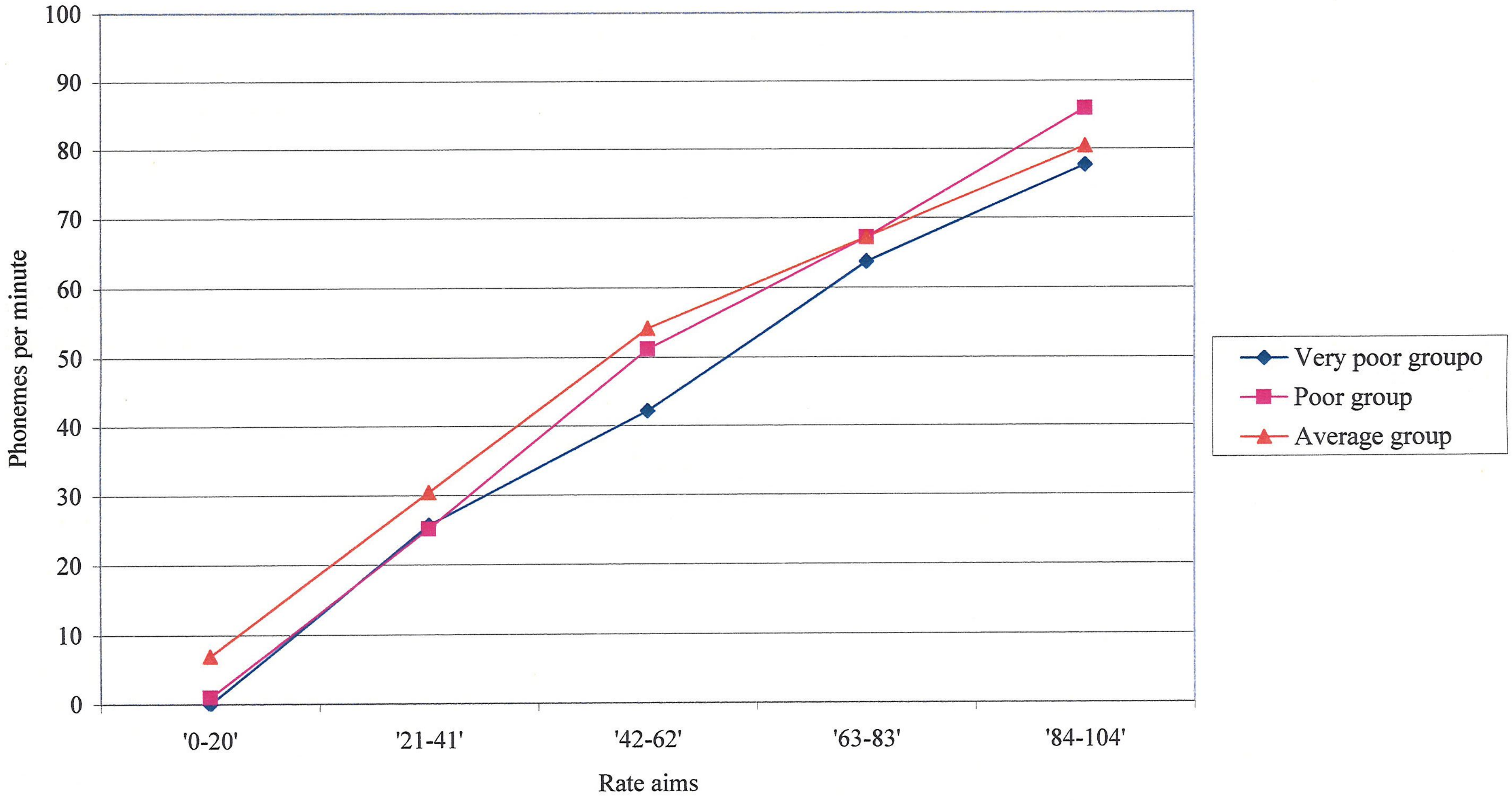

Figure 8.16: Mean correct VS rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

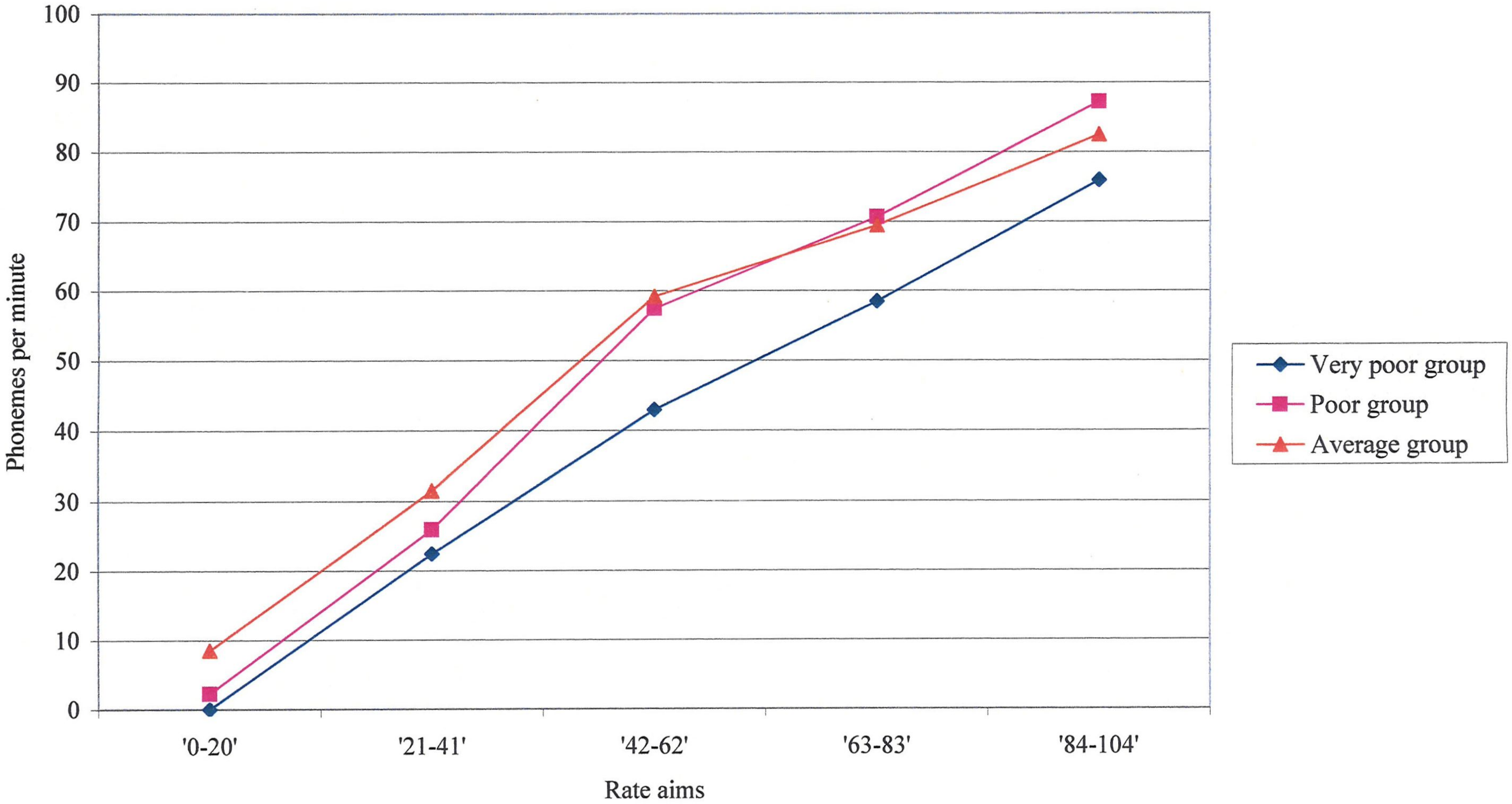

Figure 8.17: Mean correct AS rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

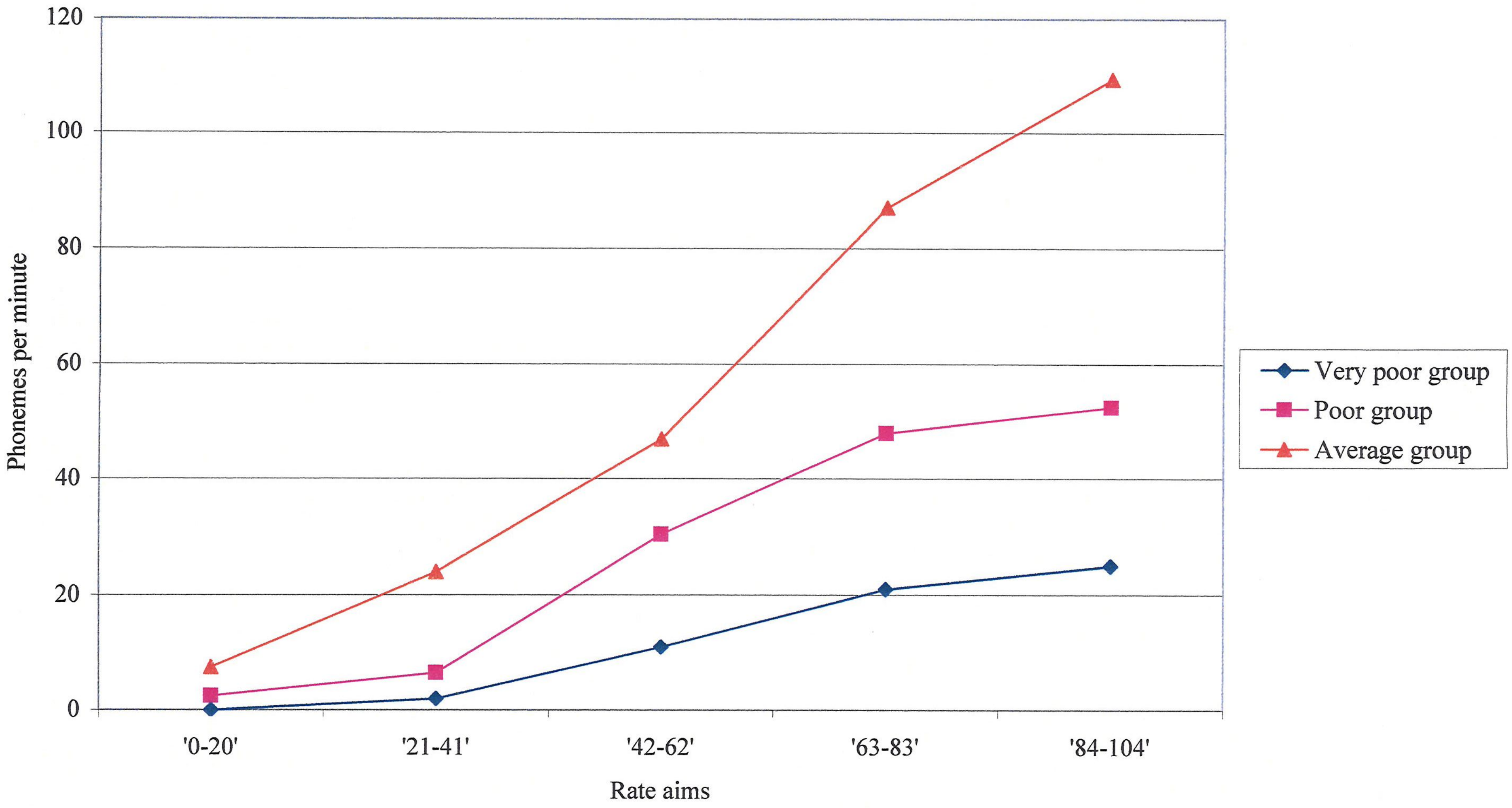

Figure 8.20: Mean correct Application 2 rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

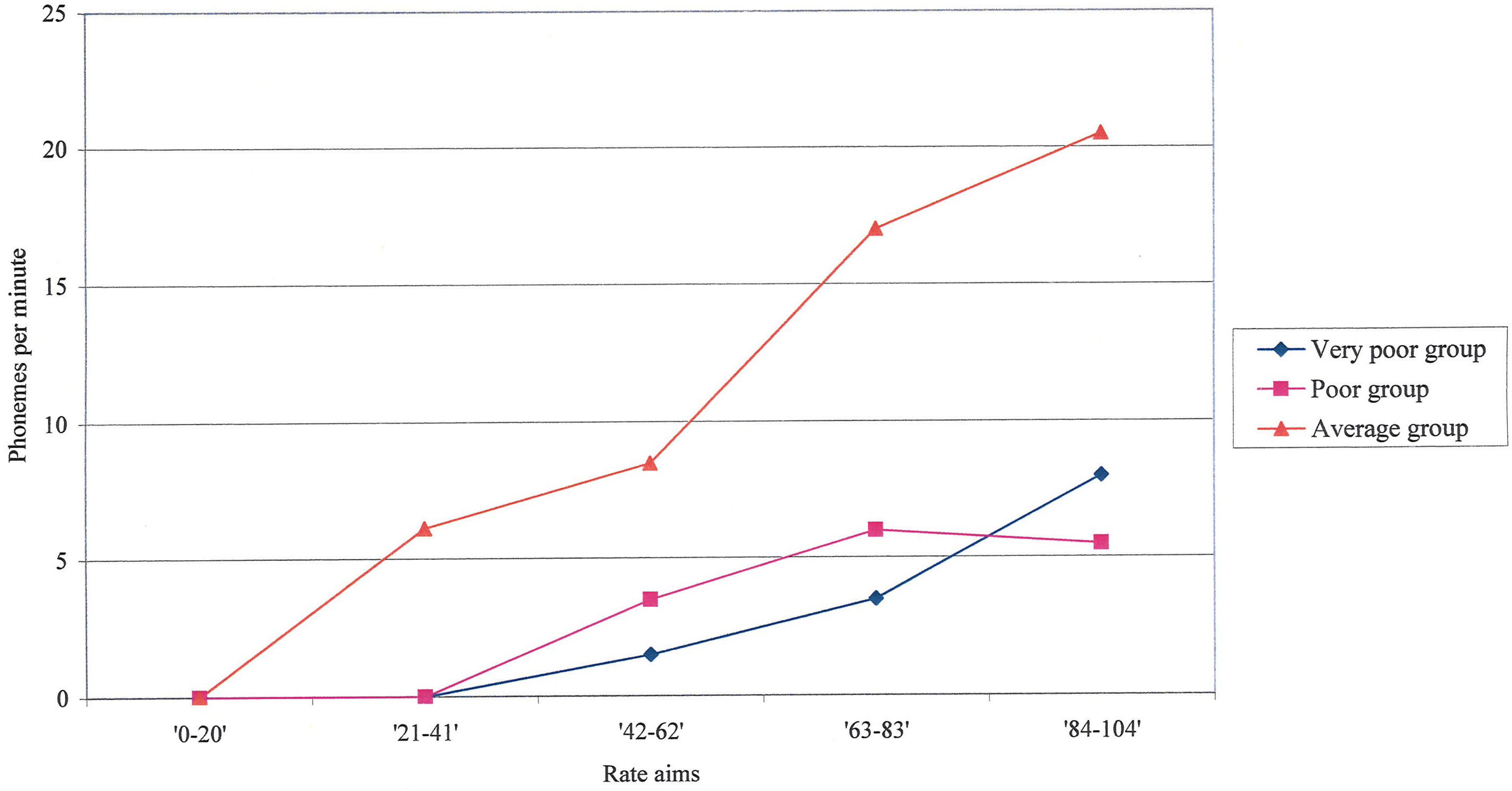

Figure 8.21: Mean correct Adduction 1 rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

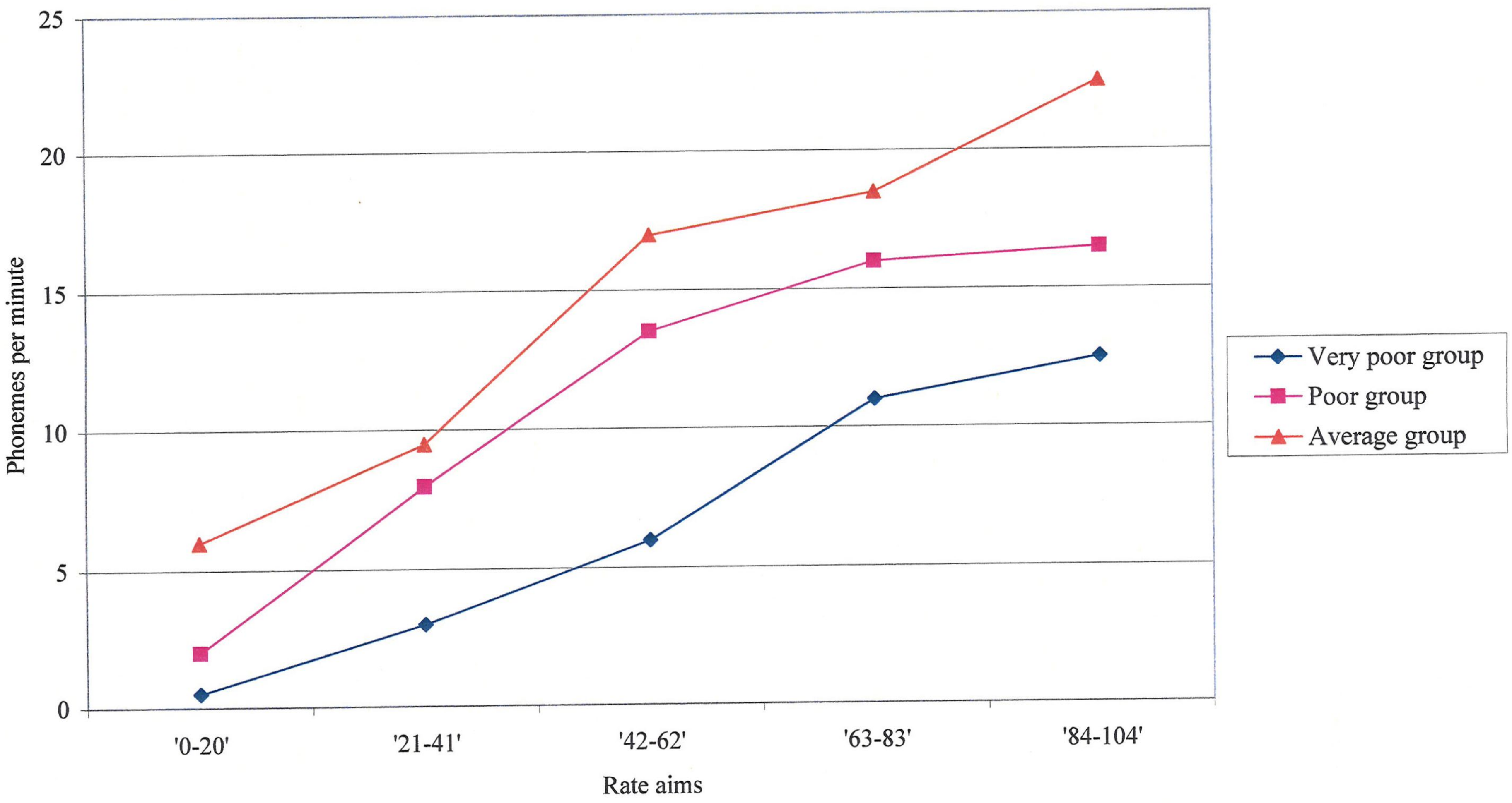

Figure 8.22: Mean correct Adduction 2 rates at each rate aim in the RB condition for the participants scoring within the very poor, the poor and the average TERA ranges

means exceeded the average TERA-3 group mean which remained very slightly lower for the following rate aim.

Group retention rates

Figure 8.14 shows the mean retention rates at each rate aim for the three TERA-3 groups. There was some difference between the group performances on the retention probes. The very poor group had the lowest mean performance compared to the other two TERA-3 groups. The average group initially showed the highest mean retention rates of the three groups, until the 63-83 ppm rate aim, at which point the poor range group mean rates slightly exceeded those of the average range group. However, there was little difference between the average and poor group performances on the retention probes. The mean retention rate data for the very poor group showed divergence from the poor and average group data after the 42-62 ppm rate aim.

Group endurance rates

The mean endurance rates at each rate aim for the three TERA-3 groups are shown in Figure 8.15. Similar trends in data were observed for the mean rates on the endurance probes as were evident for the retention probes. The very poor TERA-3 group again had the lowest mean rates at each rate aim. The performances of the other two groups on the endurance probes were similar. The average group initially had the highest mean endurance rates until the 42-62 ppm rate aim when the poor TERA-3 group mean rate exceeded and remained higher than the average TERA-3 group rate. The very poor TERA-3 group data again diverged from the poor and average TERA-3 group data after the 42-62 ppm rate aim.

Group visual stability rates

The mean VS rates, which are shown in Figure 8.16, were similar for each TERA-3 group. The very poor and poor TERA-3 group mean VS rates were very similar at the first two rate aims. After this aim the very poor TERA-3 group had slightly lower mean VS rates than the poor and average groups for the remaining rate aim probes. The average group had the highest mean VS rates until the 63-83 ppm rate aim, when the mean rate for the poor TERA-3 group was equal to that of the average group. The poor TERA-3 group then had a slightly higher mean VS rate than the average group at the final rate aim (84-104 ppm).

Group auditory stability rates

The AS mean rates are shown in Figure 8.17. The very poor TERA-3 group had consistently lower mean AS rates than the other two groups for each rate aim. The average group initially had the highest mean AS rates of the three groups until the 63-83 ppm rate aim. The poor TERA-3 group then had the highest mean AS rates of the three groups at the 84-104 ppm rate aim.

Group Combined auditory and visual stability rates

Figure 8.18 shows the mean CAVS rates for each TERA-3 group. The very poor TERA-3 group had the lowest mean CAVS rates at each rate aim. The average group again had the highest mean CAVS rates until the 63-83 ppm rate aim, at which point the poor TERA-3 group CAVS rate exceeded the average group mean and remained higher for the 84-104 ppm rate aim. The very poor TERA-3 group data diverged from the other group data after the 42-62 ppm rate aim.

Group Application 1 rates

Greater differences between the group mean Application 1 rates were evident than for the see/say rate, retention, endurance and stability rates (Figure 8.19). At the 21-41 ppm rate aim there were little differences between the mean Application 1 rates for the three groups. However, after this rate aim the average TERA-3 group mean rates increased more rapidly than the other two group mean rates. The average group maintained higher mean Application 1 rates for all successive rate aims. After the 21-41 ppm rate aim, the very poor TERA-3 group had the lowest mean Application 1 rates of the three groups at each rate aim. The poor TERA-3 group mean Application 1 rates remained lower than the average TERA-3 group mean rates but higher than the very poor group mean rates at ach rate aim after the 21-41 ppm aim.

Group Application 2 rates

Figure 8.20 shows the mean Application 2 rates for each TERA-3 group. Even greater differences than were evident for the Application 1 rates were observed for the Application 2 mean rates of the three groups. The average TERA-3 group had the highest mean Application 2 rates at each rate aim. The very poor TERA-3 group consistently showed the lowest mean Application 2 rates at each rate aim. The poor TERA-3 group had means that were constantly lower than the average group mean rates but higher than the very poor mean rates.

Group Adduction 1 rates

The average TERA-3 group had consistently higher mean Adduction 1 rates at each rate aim (Figure 8.21) than the other two groups. The poor and very poor TERA-3 groups had mean Adduction 1 rates of zero for the first two rate aims. Although both groups showed increases in mean Adduction 1 rates at the 42-62 ppm and 63-83 ppm rate aims, the mean rates were higher for the poor group than for the very poor group. However, at the 84-104 ppm rate aim, the very poor TERA-3 group had a higher mean Adduction 1 rate than the poor group.

Group Adduction 2 rates

The mean Adduction 2 rates for each TERA-3 group are shown in Figure 8.22. The average TERA-3 group had consistently higher Adduction 2 rates than the other two groups at each rate aim. The very poor TERA-3 group Adduction 2 means were constantly lower than the other two group means at each rate aim. The poor TERA-3 group had Adduction 2 mean rates that were higher than the very poor group mean rates but lower than the average group mean rates at each rate aim.

Reinforcement quantities

The quantities of reinforcement that each participant received in the RB and CRP conditions over the intervention period were tallied and charted. Figure 8.23 displays these data. Most of the children received greater quantities of reinforcement in the CRP condition than in the RB condition. Only Wesley received more reinforcement in the RB condition. However, there was only one more instance of reinforcement in the RB than in the CRP condition in this case.

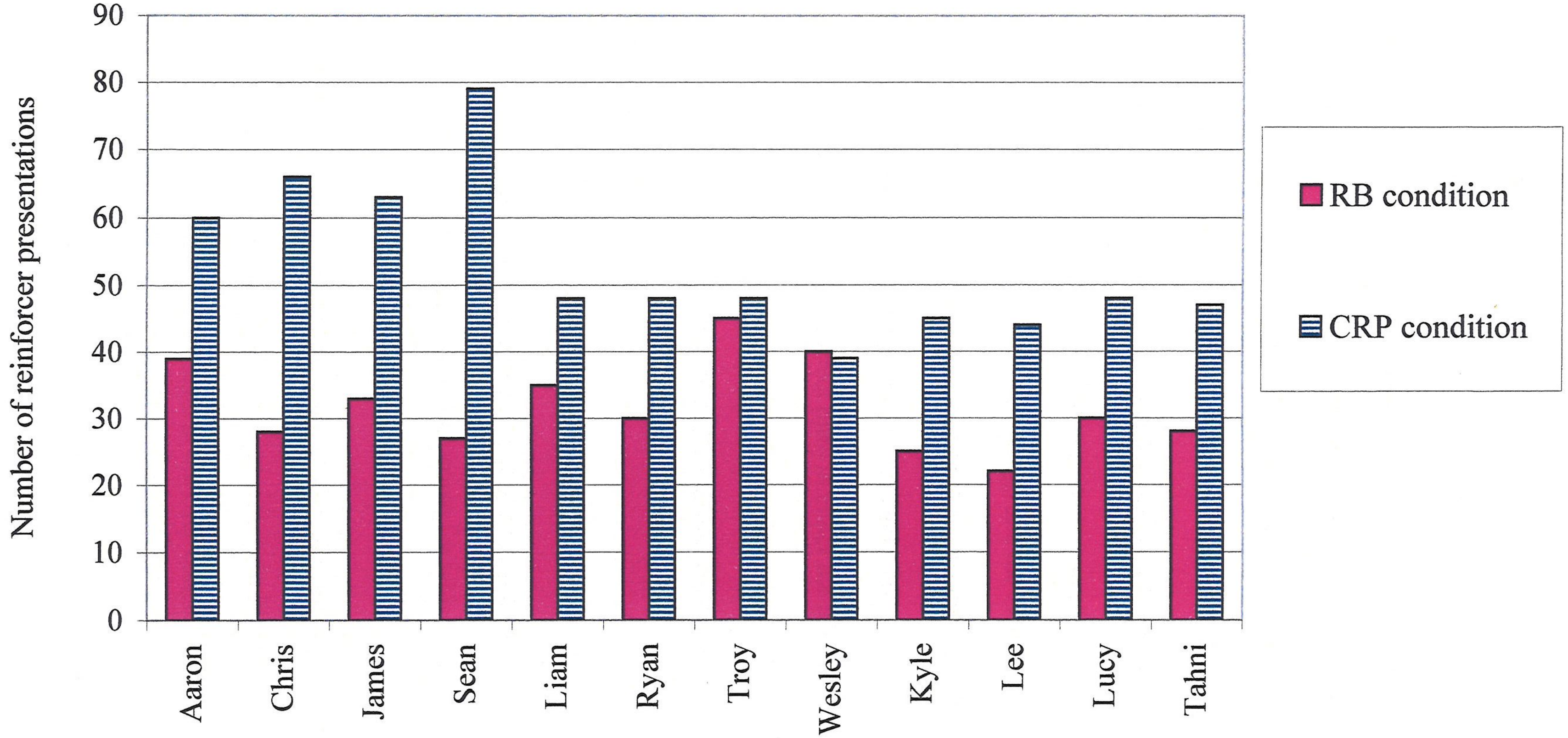

Figure 8.23: Quantities of reinforcement for each participant in the RB and CRP conditions

Summary of results

Three main forms of data analysis have been conducted for the Study 2 results. First, the see/say training rates and the RESAA rates were analyzed individually for each child and comparisons were drawn between performances in the RB and CRP conditions. Following were the comparisons of see/say training rates with RESAA rates in the RB condition for each participant over the intervention period. Comparisons were then made between the mean performances of the three TERA-3 groups at each rate aim in the RB condition. Finally, the quantities of reinforcement in the two conditions were compared.

The mean see/say training rates on the one-minute timings and the retention, endurance, stability, application and adduction rates for each TERA-3 group in the RB and CRP conditions during the intervention phase are summarized in Table 8.31. The table also shows the proportions of children that had higher correct rates in either the RB or the CRP condition for each rate measure. A far greater proportion of participants attained higher correct rates in the RB condition (71.7%) than in the CRP (25.8%) condition across rate measures during the intervention period.

The follow-up data have been summarized in Table 8.32. For most of the RESAA probes the mean correct rates during the follow-up phase were higher in the RB condition than in the CRP condition. The exceptions were for the poor group for which higher group means were evident in the CRP condition for the endurance and Application 1 probes. The very poor group also demonstrated higher correct mean rates in the CRP condition on the Adduction 1 and 2 probes. The children attained higher correct rates on a far greater proportion of the RESAA probes in the RB condition than in the CRP condition.

Table 8.31: Summary of correct rates during training and on each of the RESAA probes during the intervention phase.

Rate Measures	TERA-3 group	Group mean correct rate		Group mean incorrect rate		Participants with higher means in either condition	
		RB	CRP	RB	CRP	RB	CRP
See/say training	Very poor	67.8	41.3	6.6	4.2	4 of 4	0 of 4
	Poor	75.4	69.6	6.7	2.3	3 of 4	1 of 4
	Average	73.9	63.3	8.3	2.0	4 of 4	0 of 4
Retention	Very poor	49.6	41.0	7.1	5.0	4 of 4	0 of 4
	Poor	72.7	73.6	4.4	1.9	2 of 4	2 of 4
	Average	69.2	66.3	6.4	2.5	3 of 4	1 of 4
Endurance	Very poor	50.9	40.5	6.0	3.3	4 of 4	0 of 4
	Poor	67.0	64.1	5.5	2.3	2 of 4	2 of 4
	Average	63.0	61.2	5.1	1.9	2 of 4	2 of 4
VS	Very poor	61.3	39.8	7.4	2.7	4 of 4	0 of 4
	Poor	73.8	73	4.2	1.6	2 of 4	2 of 4
	Average	72.5	68.1	5.5	0.8	4 of 4	0 of 4
AS	Very poor	50.8	38.1	7.3	3.4	4 of 4	0 of 4
	Poor	75.8	72.2	4.6	9.6	3 of 4	1 of 4
	Average	73.5	66.7	6.0	2.3	4 of 4	0 of 4

Table 8.31 continued

Rate Measures	TERA-3 group	Group mean correct rate		Group mean incorrect rate		Participants with higher means in either condition	
		RB	CRP	RB	CRP	RB	CRP
CAVS	Very poor	56.7	35.2	7.1	2.3	4 of 4	0 of 4
	Poor	73.5	69.8	5.1	1.8	3 of 4	1 of 4
	Average	70.6	65.4	4.5	1.8	4 of 4	0 of 4
Application 1	Very poor	22.6	16.0	6.4	9.5	4 of 4	0 of 4
	Poor	41	41.8	6.9	6.0	1 of 4	3 of 4
	Average	43.6	49.7	6.6	4.9	1 of 4	3 of 4
Application 2	Very poor	22.4	19.5	8.3	10.6	4 of 4	0 of 4
	Poor	52.2	50.8	6.1	7.6	2 of 4	2 of 4
	Average	64.0	72	7.9	5.3	2 of 4	2 of 4
Adduction 1	Very poor	6.1	5.2	8.7	8.0	2 of 4	1 of 4
	Poor	6.1	5.4	8.1	8.4	3 of 4	1 of 4
	Average	16.8	14.5	4.5	7.7	2 of 4	2 of 4
Adduction 2	Very poor	10.4	10.1	3.4	4.1	2 of 4	2 of 4
	Poor	16.7	15.1	22.7	21.3	2 of 4	1 of 4
	Average	19.3	20.2	1.3	1.0	1 of 4	2 of 4
Total proportions						71.67%	25.83%

Table 8.32: Summary of correct rates on the long-term follow-up RESAA probes.

Rate Measure	TERA-3 group	Group mean correct rate		Group mean incorrect rate		Participants with higher means in either condition	
		RB	CRP	RB	CRP	RB	CRP
Retention	Very poor	56.0	50.0	13.0	9.5	2 of 2	0 of 2
	Poor	95.0	85.3	2.7	1.7	3 of 3	0 of 3
	Average	76.5	60.5	5.3	1.8	3 of 4	0 of 4
Endurance	Very poor	54.0	51.5	6.0	5.5	1 of 2	1 of 2
	Poor	84.0	86.7	1.0	1.0	1 of 3	2 of 3
	Average	75.0	64.8	1.0	4.0	3 of 4	1 of 4
VS	Very poor	60.5	55.5	7.0	9.0	2 of 2	0 of 2
	Poor	107.0	91.3	2.0	3.0	3 of 3	0 of 3
	Average	88.5	74.0	1.8	4.8	3 of 4	1 of 4
AS	Very poor	61.0	54.0	8.5	9.0	2 of 2	0 of 2
	Poor	104.7	85.3	2.0	2.7	3 of 3	0 of 3
	Average	87.0	71.0	1.8	4.8	4 of 4	4 of 4
CAVS	Very poor	54.0	49.0	9.5	9.0	2 of 2	0 of 2
	Poor	97.7	83.3	2.7	4.0	2 of 3	0 of 3
	Average	79.3	63.3	2.3	5.3	4 of 4	4 of 4

Table 8.32 continued

Application 1	Very poor	45.0	30.0	5.0	5.0	2 of 2	0 of 2
	Poor	80.7	86.0	2.0	0.7	1 of 3	2 of 3
	Average	86.0	68.5	2.0	2.5	4 of 4	0 of 4
Application 2	Very poor	42.0	37.0	4.0	7.0	1 of 2	1 of 2
	Poor	111.3	109.3	0	0	1 of 3	1 of 3
	Average	94.5	92.5	2.8	5.0	3 of 4	1 of 4
Adduction 1	Very poor	8.0	12.0	9.0	11.0	1 of 2	1 of 2
	Poor	19.3	19.3	5.3	4.0	1 of 3	1 of 3
	Average	26.0	21.0	6.0	5.0	2 of 4	2 of 4
Adduction 2	Very poor	16.0	17.0	3.0	2.0	1 of 2	1 of 2
	Poor	22.7	21.3	0.7	0.7	3 of 3	0 of 3
	Average	23.0	23.0	0.5	0.5	4 of 4	0 of 4
Total proportions						62/81	23/81
						76.5%	28.4%

The comparisons of the correct see/say training rates in the RB condition to the correct RESAA rates in the RB condition showed most of the children in the very poor TERA-3 group had lower RESAA rates than see/say training rates at most rate aims. There were much smaller differences between the see/say training rates and the retention, endurance and stability rates compared to between the see/say training rates and the application and adduction rates for this group of students. The participants who scored within the poor range on the TERA-3 generally had similar see/say training rates to retention, endurance and stability rates at most rate aims. However, there were again much larger differences between the see/say training rates and the application and adduction rates for this group of children. The students in the average TERA-3 range also demonstrated similar see/say training rates to rates on the retention, endurance and stability probes at most rate aims. Again there were much greater differences between their see/say training rates and their application and adduction rates. It was also observed that where see/say training rates and retention, endurance and stability rates showed a sudden and rapid increase, this shift commonly occurred around the 84-104 ppm rate aim for the see/say training rates and retention, endurance and stability rates. Spontaneous increases in data on the application and adduction probes were often evident at higher rate aims of around 105-125 ppm.

The group comparisons of mean rates at each rate aim showed that each TERA-3 group attained similar mean see/say training rates from the 0-20 ppm to the 84-104 ppm rate aims. The mean rates were also very similar for the poor and average TERA-3 groups on the retention, endurance and stability probes at each of these rate aims. The very poor TERA-3 group had consistently lower means at each rate aim than the other two groups for the retention, endurance and stability probes. Much greater differences between the mean group rates at each rate aim were evident for the application and adduction probes. On the Application 1 probes, the three groups had very similar mean rates at the 21-41 ppm rate aim. However, after this aim, the very poor group consistently demonstrated the lowest mean rate on each successive probe, whilst the average group consistently had the highest mean rate on each aim. The poor TERA-3 group performed at mean rates that were lower than the average group but higher than the very poor group at each rate aim. Even larger differences were evident between the data for the three groups on the Application 2 probes. The average TERA-3 group had the highest mean rate at all rate aims, whilst the very poor group consistently showed the lowest mean rates. The poor TERA-3 group again showed mean rates that were lower than the average group but higher than the very poor group. For the Adduction 1 probes the average TERA-3 group consistently had the highest mean rates at each rate aim in the intervention phase and the poor and very poor groups demonstrated similar mean rates to one another. The poor group and very poor groups had mean rates of zero for the first two rate aims after which the poor group attained higher mean rates for most of the following rate aims. However, at the final rate aim of 84-104 ppm the very poor TERA-3 group demonstrated a higher mean rate than the poor group. The group comparisons for the Adduction 2 probes indicated that the average TERA-3 group had higher mean rates at each rate aim, whilst the very poor group had the lowest at each aim. The poor group achieved mean rates that were higher than the very poor group but lower than the average group at each rate aim.

Overall, the results showed that higher see/say training rates were generally attained more often on the one-minute timings in the RB condition than in the CRP condition. They also indicated that superior performance was most often evident in the RB condition for most RESAA probes. For the majority of the children, the see/say training rates were higher than the RESAA rates attained on the probes by each participant in the RB condition. Group comparisons revealed that there were little differences between the mean see/say training rates of the three TERA-3 groups at each rate aim from the 0-20 ppm to the

84-104 ppm rate aims. However, differences between the three groups began to emerge on the retention, endurance and stability measures after the 21-41 ppm rate aim, although the data for the poor and average groups remained relatively similar for these probes. Much larger divergences in data for the three groups were observed on the application and adduction probes. For these measures it was common for the group means to be the highest for the average group and lowest for the very poor group at most rate aims after the 0-20 ppm rate aims in the intervention phase.

CHAPTER 9

DISCUSSION FOR STUDY (2)

The results of Study 2 are discussed in this chapter. First, comparisons of the see/say training rates and then the RESAA rates in the RB and CRP conditions are discussed. Next, the comparisons between the performances of the very poor, poor and average reading ability groups are examined. The three-month follow-up data are then discussed and the chapter ends with a brief conclusion of the results and implications of Study 1 for research and practice. In Chapter 10, a more detailed discussion is presented of the general findings of Studies 1 and 2 in relation to the theoretical models and concepts used to explain the results.

Comparisons of see/say training rates between conditions

The baseline correct rates on the one-minute timings in the RB and CRP conditions were very low for each child and ranged from 0 ppm to 7 ppm in the RB condition and from 0 to 6 ppm in the CRP condition. Thus, there was very little difference between the correct see/say training rates in the two conditions prior to the commencement of the intervention.

The correct see/say training rates increased in both conditions for all of the participants. Both the rate building exercises in the RB condition and the repeated practice of the digraphs at a constrained slow-paced speed in the CRP condition led to increased see/say phoneme rates at each incremental rate aim. The increases in correct rates in the CRP condition are most likely to have been the result of repeated practice. Other researchers have reported increased response rates after non-timed repeated practice (Omrod & Spivey, 1990; Bonser, 2002; Shrivastava, 2000). However, these results may also have been partially attributable to unavoidable carry-over effects.

Although efforts were made to counterbalance any order effects, such as randomly assigning the participants to begin training in either the RB or the CRP conditions, the within-subjects design meant that each child participated in treatments in both conditions. Thus, although the children were not explicitly trained to build see/say phoneme rates for the set allocated to the CRP condition, repeated practice in building rates of the phonemes assigned to the RB condition and the free-rate probes conducted after constrained-rate practice may have influenced increases in response rates in the CRP condition.

Although increases in correct see/say training rates were evident in both conditions over the intervention phase, all but one of the 12 children in the study attained higher mean correct see/say training rates in the RB condition than in the CRP condition during the intervention period. There were significant differences between conditions for the very poor and average groups ($t = 0$, $p < 0.05$). Only one child, who scored within the poor range on the TERA, achieved a slightly higher mean correct rate during training in the CRP condition than in the RB condition. Overall, the results showed that the speeded practice during the rate-building exercises in the RB condition was more effective in increasing the correct see/say phoneme rates during training than the same amount of repeated practice at a constrained rate for eleven of the twelve children. The finding that the timed repeated practice, with an emphasis on speed, was more effective in increasing response rates than repeated practice at a slow pace is consistent with other research (e.g., Omrod and Spivey, 1990; Bucklin et al., 2000). These findings included the effects of using probes of freer-rate responding after the constrained rate trials, as suggested by Binder (2004). Measures comprising only percentage correct scores would provide no further means of comparison of the effects of the training procedures on performances beyond the attainment 100% accuracy. Thus, as most of the children achieved high levels of accuracy by the second or third rate aim, it would have been impossible to observe any differences in performances between the two conditions over the remainder of the intervention period. Therefore, in answer one of the questions posed to researchers by Binder (2004): rate did provide for more information than percentage correct scores.

The baseline timings specifically highlighted the sensitivity of rate measures and their advantage over percentage correct scores. Under the free-operant conditions in which the timings were conducted, the children were able to make many responses to a single stimulus. A common and repeated observation made during these timings was that the children who attained low rates would make a correct response for a particular digraph on one repetition but then when they encountered the same digraph again, they would respond incorrectly. Thus, the rate assessment demonstrated that although a child may have responded correctly once or twice to a particular digraph, their response to that phoneme was by no means consistent and was accurate on less than half of the repetitions. It could be concluded, therefore, that the child did not have functional knowledge of that digraph. Had the set of digraphs been assessed using percentage correct scores, a participant may have responded correctly to that digraph on that particular trial and it would have been inappropriately assumed that the child had adequate knowledge of that digraph. Consequently, these observations support the assertion by many researchers that rate measures are far more sensitive and a much more appropriate measure of learning behaviour than percentage correct scores (Kunzelmann, Cohen, Hulten, Martin & Mingo, 1970; Skinner, 1953; Lindsley, 1991; 1996; Binder, 1988; 1990a; 1990b; 1996; Bolich & Sweeney, 1996).

The baseline incorrect rates in the two conditions varied between participants, although there were little differences between the rates in the two conditions for each individual. The baseline incorrect rates across the groups and conditions ranged from 4 ppm to 54 ppm. These rates decreased in both conditions for each participant over the intervention period and are consistent with the results of Study 1 in which incorrect rates also decreased as correct rates increased, even though error rates were not specifically targeted. Other researchers have reported similar inverse relationships between correct and incorrect rates when error rates were not explicitly targeted for intervention (Bolich & Sweeney, 1996; Herman, 1985; Samuels, 1997). Theoretical explanations for these findings are discussed in Chapter 10 as they relate to the findings in both Studies 1 and 2.

Comparisons of see/say training rates to RESAA rates

For most of the RESAA probes in the baseline phase there were very little differences between the participants' performances in the two conditions. Thus, any differences in the performance rates between conditions produced during the intervention phase were likely to have been the results of the differential effects of the treatment procedures in the RB and CRP conditions.

Most of the children involved in Study 2 demonstrated increases in correct rates on the RESAA probes over the intervention period in both conditions. However, the mean correct rates were higher for each group in the RB condition than in the CRP condition for 81.5% of the RESAA probes and the results showed that individual participants achieved higher correct rates on a far greater proportion of the RESAA measures in the RB condition (71.7%) compared to in the RBAAT condition. The rates were equal in the two conditions for individuals for 2.5% of the RESAA measures.

Thus, overall, these results demonstrated that building the speed of see/say phoneme rates generally produced higher rates on the RESAA measures than the same amount of practice at a constrained, slow speed. The finding that the correct rates were generally higher on the RESAA probes in the RB condition than in the CRP condition is in accord with the results of other studies that have compared the effects of setting rate criteria with accuracy criteria on some of the RESAA outcomes (e.g., Bucklin et al., 2000). These results also provide empirical evidence to answer another of the questions posed for researchers by Binder (2004): the rate of response is a better predictor of the learning outcomes that the traditional percentage correct measure. At the first two rate aims, the children’s error rates generally decreased to around two errors per minute. Thus, they were attaining high levels of accuracy. However, it was not until the children’s correct rates reached around 100 ppm that the children began to demonstrate significant gains on some of the RESAA measures, particularly for the application and adduction outcomes. Percentage correct scores lack the time dimension and, therefore, could not predict the quantity of practice, beyond 100% accuracy that was required to predict the learning outcomes.

Most studies that have investigated the effects of rate-building on specific outcomes have not controlled for the quantity of practice (Doughty, Chase & O’Shields, 2004; Kuhn & Stahl, 2003). Therefore, it could be argued that in these studies any superior gains may have been the result of increased quantities of practice, rather than being attributable to higher response rates. As the quantity of practice in the two conditions was equal in the current study, the studies overcame this limitation and demonstrated conclusively that the speed of responding was the factor producing the higher rates on the RESAA measures, rather than greater quantities of practice. These findings are consistent with Shrivastava’s (2000) study which also investigated the effects of increased response rates on the RESAA measures and controlled for practice effects through similar methods applied in the current study.

A general observation was that the higher the mean training rate a child achieved in the RB condition, the higher the mean rates that child attained on the RESAA probes. However, there were specific instances in which data did not strictly follow this trend. For example, James achieved a slightly higher mean training rate than Christopher but Christopher then attained a higher mean rate on the endurance probes than James. However, the difference between their mean training rates was only 2 ppm which was negligible. Overall higher training rates generally produced higher rates on the RESAA probes. These findings support other studies that have compared the effects of different training rates on some learning outcomes and shown that attainment of the higher aims produced superior performance on learning outcome measures (e.g., Evans, Mercer & Evans, 1983; Ivarie, 1986). One child showed no increases in correct rate on some of the RESAA probes even though his training rate increased over the intervention period. Sean, who scored within the very poor range on the TERA, did not demonstrate any increases in correct rates on the Adduction 1 probes in either condition, nor on the Application 2 probes in the CRP condition, and his performance rates increased only minimally in the RB condition on the Application 2 and on the Adduction 2 probes in both conditions over the entire intervention period. The finding that he achieved the lowest training rates in both conditions of any of the children implied that he had not attained sufficient see/say phoneme rates during training to facilitate improvements on all of the RESAA measures. His rates of 56 ppm in the RB condition and 23.8 ppm in the CRP condition are considered low rates by many researchers and practitioners

(Johnson & Layng, 1994; Kuhn et al., 2003; Beck & Clement, 1991; Polk & Miller, 1994; Mercer, Mercr & Evans, 1986; Haughton, 1972; Evans, Mercer & Evans, 1983; Mounsteven, 1990; Lindsley, 1996b). In comparison, Wesley who scored within the poor range on the TERA, demonstrated the highest mean training rates of all of the children in the study in both conditions. He also achieved the highest mean rates of all of the participants for 66.7% of the RESAA probes in both conditions. These individual examples further highlight how higher training rates appear to have produced higher rates on the RESAA measures.

The training correct rate data for the RB condition were included on each of the figures that displayed the RESAA rates for each child. These comparisons showed that although the rates on the RESAA probes generally increased as the training rates increased at each rate aim, it was not common for the RESAA rates to increase to the same levels as the training rates. Doughty, Chase and O'Shields (2004) reported similar findings in their review of rate-based studies. Both individual participant data and mean group data generally indicated lower RESAA rates than training rates in the RB condition.

Questions concerning what constitutes adequate performance on the RESAA measures arose from the findings that RESAA rates were generally lower than training rates. Johnson and Layng (1996) defined the retention, endurance and stability outcomes and the conditions under which these are tested. They asserted that these outcomes occur when performance is maintained under these conditions at the same rate as during training (p. 285). However, these definitions are problematic. A common finding in the current study was that, at the lower rate aims, some of the RESAA rates often reached the same levels as the training rates. For example, Aaron's retention rates in the RB condition were higher than his RB training rates at the 21-41 ppm and 63-83 ppm rate aims (Figure 13.1, Appendix 11). According to Johnson and Layng's (1996) definition, Aaron had demonstrated skill retention when his training rate was as low as 28 ppm. This may have been an accurate assumption, as although a training rate of 28 ppm would not be considered fluent performance by most practitioners, Johnson and Layng (1996) maintain that fluent performance is indicated by response rates that predict <u>all</u> of the RESAA outcomes, or at least the first four. Thus, the finding that Aaron achieved the retention outcome when his rate was as low as 28 ppm may have suggested that skill retention occurs at lower rates than some of the other RESAA outcomes. What makes the definition problematic, however, is that although his retention rate again exceeds his training rate at the 63-83 ppm rate aim, the retention rates did not reach the training rate levels for any of the other rate aims. In fact, the difference between the two rates became increasingly larger as he attained progressively higher training rates. These findings were repeated for other participants on various RESAA probes. Thus, the question arises as to whether the children had actually reliably demonstrated an outcome if particular RESAA rates only exceeded their training rates occasionally and usually at the lower rate aims.

The second problem that was encountered in the present study related to the definitions of application and adduction. Johnson and Layng (1996) defined application as the ability to "easily apply the skill as a prerequisite or component of a more complex performance to be learned" (p. 285) and adduction as the ability to "demonstrate increasing capacity to learn skills instantly, on their own, as they move through a subject matter" (p. 285). In neither definition is a mention of a performance rate to indicate that these outcomes have been adequately demonstrated. Johnson and Layng

(1996) go on to illustrate these definitions with an example in mathematics. In the example, they state that skill application is demonstrated when learners can “apply their math fact skills in learning new component and composite sequences…. without having to pause to recall math facts, disrupting completion of the new learning tasks” (p. 286). Again, however, there is no description of a rate, or of the number of times the skill has to be performed, for application or adduction to be considered as having been demonstrated.

If skill application and adduction were considered to be demonstrated in the same manner as retention, endurance and stability, none of the children in this study demonstrated application and adduction as their rates on these probes were not as high as their training rates. Thus, it might be argued that most of the children did not reach fluent levels of performance. This may indeed have been a precise supposition. However, it may be implausible to expect that performance rates on the adduction outcomes should reach training rate levels. Although the adduction tasks were designed to minimalize external restrictions on response rates, the time taken for the next word to be given would place unavoidable minor restrictions on the rates achieved on these timings. Likewise, the motor movement of circling phonemes during the Adduction 2 probes could be expected to be slower than the oral production of digraph sounds. These considerations then generate questions concerning the speeds that would be considered acceptable to indicate skill adduction had occurred. On the other hand, the lack of reference to the speed of responding in the application and adduction definitions by Johnson and Layng (1996) may suggest that learners have to demonstrate less precise evidence of application and adduction for these outcomes to be considered adequately demonstrated. If some evidence of performance of the see/say phonemes skill within the context of composite tasks was the criterion, then eleven out of the twelve participants would be considered to have demonstrated skill application and adduction. However, would it be reasonable, for example, to assume that a child who demonstrated application of the skill once, or who performed an adduction task at a rate of only two responses per minute had successfully demonstrated these learning outcomes? Or, should there be evidence of application and adduction that is demonstrated on a number of occasions before the outcomes are considered “achieved”?

The complexities arising from ambiguous definitions of the RESAA outcomes made it difficult to ascertain whether the children in the current study reached fluent levels of performance based on comparisons of mean training and RESAA rates alone. However, a distinct change in the slope of RESAA data in the RB condition was commonly observed at around the 105-125 ppm and the 126-146 ppm rate aims. At these rate aims, it was frequently observed that the RESAA data often showed spontaneous and rapid increases towards the training rate levels for the participants with the highest training rates, such as Wesley, Kyle and Lee. Although these trends in data do not allow for the specification of one particular rate to ensure evidence of “fluent performance” for all individuals, they do support the claims by other precision teachers that fluent performance on a phoneme learning task is at least 100 responses per minute. They also showed that rapid gains in rate on the RESAA probes, and particularly on the application and adduction probes, began to occur when the training rates exceeded 120 responses per minute. These findings implied that the attainment of higher training rates may have predicted even greater degrees of application and adduction outcomes had the study continued and produced higher training rates. The current study was conducted within the confines of a restricted time period and future studies are warranted to investigate the effects on the RESAA measures of even higher training rates.

<u>Comparisons between the TERA-3 groups</u>

There were minimal differences between the baseline performances of the children in the three reading ability groups in each condition. The very poor children each demonstrated 0 ppm correct rates on the one-minute timings, the poor children's rates ranged from 0 ppm to 5 ppm, and the average children attained rates ranging from 0 ppm to 7 ppm. Thus, any differences that were observed between the performances of the groups during and after the intervention were likely to reflect the effects of the levels of reading ability of the children on the relative efficiency of the treatment procedures.

The group comparisons of the mean see/say training rates at each rate aim in the RB condition revealed that the children in the very poor, poor and average groups demonstrated similar mean correct training rates over the intervention phase (Figure 8.13, p. 296). These findings indicated that regardless of the level of assessed reading ability, all of the children were able to attain similar rates up to the 84-104 ppm rate aim. After the study was completed, the number of phoneme repetitions required by the children in the three TERA-3 groups was counted. The results indicated that although the children in each group were able to acquire similar training rates at each rate aim, the children in the very poor TERA-3 group required far more phoneme repetitions to attain these training rates than the children in the other two TERA-3 groups. The children in the poor TERA-3 group required a far greater number of phoneme repetitions than the children in the average TERA-3 group. All but one of the children also demonstrated rates beyond the 84-104 ppm rate aim. The highest rate aim of 147-

167 ppm was achieved by a child in the poor group. Most of the other children reached the 105-125 ppm and 126-146 ppm rate aims. These results suggested that the level of reading ability of the children did not have a significant effect on the children's ability to build comparable training rates within an equal time period.

Although the training rates of the three groups were similar in the RB condition, differences in group performances on the RESAA probes in this condition were evident. The data for the retention, endurance and stability probes for the children in the very poor group were observed to diverge from the poor and average group data, and the mean rates for the very poor group remained lower than those of the poor and average groups at most rate aims. The poor and average group data were relatively similar on these figures (Figures 8.14 to 8.18, p. 297-301). These data implied that the children in the very poor group did not demonstrate the same degree of retention, endurance and stability as the poor and average group children even though they attained similar training rates. In other words, similar training rates did not predict the same levels of retention, endurance and stability for the very poor participants as for the children in the other two groups.

On the Application 1, Application 2 and Adduction 2 probes (Figures 8.19 to 8.22, p. 302-305), the mean rate data for the very poor group showed a gradually greater degree of divergence from the other group data at each successive rate aim, than was observed for the retention, endurance and stability data. Thus, the children in the very poor group demonstrated the lowest levels of skill application and adduction, even though mean training rates were similar across groups. In addition, the results also showed that the application and Adduction 2 data for the poor group diverged from the average group data at each rate aim. On the Adduction 1 probes, even greater divergence between the poor and average group data were observed than for any of the other probe data. Thus, although similar training rates predicted similar rates on the retention, endurance and stability measures for the poor and average groups, but not for the very poor group, similar training rates did not ensure similar levels of performance on the application and adduction probes for any of the groups. These findings suggested that retention, endurance and stability possibly occurred at lower training rates than application and adduction.

A number of implications can be drawn from the group comparisons of the RB training rates and RESAA probe data. First, the similarity in mean training rates at each rate aim for the three groups indicated that the level of reading ability did not affect the attainment of similar see/say training rates. Second, the disparity in RESAA rates between the groups at each rate aim highlighted that the level of reading ability of the participants did have a significant effect on their achievement of correct rates on the RESAA probes, and particularly on the application and adduction probes. Thus, it can be concluded that one specific training rate of see/say phonemes did not predict the same levels of performance on the RESAA measures for all of the children. Rather, the average ability individuals were able to attain higher rates on the RESAA probes than the other two groups at similar training rates. The poor group also demonstrated higher RESAA rates than the very poor group at similar training rates. The results imply that the very poor group may have had to build higher training rates than the other two groups to ensure the same level of performance on the RESAA measures as the children of higher reading ability. Likewise, the poor group may have had to attain higher training rates than the average group to predict the same levels of performance on the RESAA measures.

Reading ability group comparisons also showed that the achievement of a particular rate during training did not ensure the same level of performance on each RESAA measure for a particular group. The mean group rates for each RESAA probe were placed in rank order from the highest mean to the lowest mean for each group. Although there were slight variations in the order of the outcomes between groups, some general trends were observed. Higher mean rates were generally achieved on the retention, endurance and stability measures than for the application and adduction outcomes for each group. The only exception was for the average group for which the Application 2 mean was very slightly higher than the endurance mean by 1 ppm. The application means were higher than the adduction means for each group. The lowest means attained on the probes for the three groups were for the adduction outcomes. These findings showed that a particular group training rate did not predict the same levels of group performance on all of the RESAA measures. Moreover, retention, endurance and stability data tended to show more rapidly accelerating slopes at lower rate aims than the application and adduction data for most individuals. These results further support the conclusion that the attainment of a particular rate aim did not ensure the same level of performance on all of the RESAA measures for an individual. They also imply that evidence of skill retention, endurance and stability was generally observed before evidence of application and adduction. Likewise, evidence of skill application was generally observed before skill adduction. Thus, there were essentially three distinct “levels” of generalization depicted in RESAA (RES, A, and A) and each occurred at different training rates. The implication was that progressively higher training rates would be necessary to predict the outcomes at each “level”.

The Adduction 1 task was revised from the oral segmentation task in Study 1 to an oral spelling task using the letter names in Study 2. The amendment was made after a possible limitation in the former study was revealed when the participants were able to perform the task at low rates during the baseline phase without any knowledge of the digraphs. In Study 2 each of the children demonstrated correct rates of 0 ppm in both conditions on the Adduction 1 baseline probes, suggesting knowledge of the digraphs was a pre-requisite to successful completion of the revised task. Therefore, the modified task overcame the limitation that existed in Study 1.

The findings in the current study that all of the participants attained higher rates on the Adduction 2 probes than on the Adduction 1 probes indicated that adduction was greater for a two-channel cross than a one-channel cross. These findings contrast those of Shrivastava (2000) who also assessed the levels of adduction for one-channel and two-channel crosses. Lindsley (1990) suggested that the limited research that had been conducted into learning-channels indicated that learning in one channel was independent of another. Shrivastava (2000) predicted that adduction should be greater for a one-channel cross task than for a two-channel cross task and used similar tasks to those involved in the current study during training and to assess adduction. The current findings were not consistent with the hypothesis that greater adduction occurs for a one-channel cross than for a two channel cross after training a component skill to a specific rate. However, the results may reflect differences in task complexity between the Adduction 1 and Adduction 2 activities in the present study. Shrivastava (2000) used a hear-write task to assess adduction across two learning channels. In the current study, this form of test was avoided as inaccurate or low rates of writing letters may have limited the rates at which the participants could write the pseudowords. Instead, the hear/mark task was employed in which the children had to simply draw a circle around the correct phonemes in the appropriate order. However, the digraphs and single phonemes that were printed on the worksheets may have served as visual prompts. Also, there were a finite number of responses the children could make on these worksheets. In contrast, no such prompts were available during the hear/say Adduction 1 task in the current study, and there were an infinite number of possible responses the children could have made on these tests. Therefore, in retrospect, the Adduction 1 task was possibly more difficult for the children than the Adduction 2 task. The results concerning adduction across one and two channels were inconclusive and future studies are required to further investigate the relationship between learning channels, difficulty levels and learning outcomes.

There were greater differences between the performance rates in the RB and CRP conditions for the very poor children (26.6 ppm) than for the poor (5.8 ppm) and average (10.5 ppm) groups. Greater differences were also observed between the RESAA rates in the RB and CRP condition for the children in the very poor group than for the individuals in the other two ability groups. Therefore, consistently greater gains in rate were evident in the RB condition for the children in the very poor group than for the participants in the other two ability groups. These findings are consistent with those reported by Ivarie (1986) who also found that children who were categorized as of higher ability made fewer relative gains than the children categorized as lower ability students. Ivarie (1986) trained 120 fourth grade students to translate Arabic to Roman numerals to lower (35 per minute) and higher (70 per minute) rate aims. The students were categorized as above average, average and below average according to scores on the math computation section of the Iowa Test of Basic Skills. The results indicated that three months later there was little difference between the above average students' scores in the low rate aim or high rate aim groups. However, the students in the average and below-average categories had significantly higher scores on the tests when they had trained to the higher rate aim. Thus, these results and the findings of the current study suggest that the lower the ability level of the children, the greater the effect and need of building higher response rates.

The greater differences in performance rates between the two conditions for the children in the very poor group, compared to the differences between conditions for the poor and average group children, may relate to differences in naming speeds. As naming speed, including letter-naming speed, is one of the best predictors of future reading success (Speece, Mills, Ritchey & Hillman, 2003; McCormick, Stoner & Duncan, 1994; Adams, 1990; Blachman, 1984; Walsh, Price & Gillingham, 1988) and impaired readers often demonstrate slower letter naming speeds than average readers (Deeney, Wolf & O'Rourke, 2001; Meyer, Wood, Hart & Felton, 1998; Wolf & Bowers, 2000; Wolf, Bally & Morris, 1986), it is likely that the very poor readers had slower naming speeds than the poor or average children in Study 2. Involving these children in the rate-building exercises in the RB condition would have specifically addressed this deficit, as the RB procedures improved the speed at which the participants named digraph-sounds. In the CRP condition, naming speeds were not specifically targeted and thus, any deficits in naming speeds were likely to persist for the set of phonemes allocated to this condition for the children in the very poor group. Although based on extensive research, this hypothetical explanation is tentative as naming speeds were not specifically assessed prior to the commencement of the study. Future research may replicate the current study but include naming speed tests before the intervention commences to ascertain whether any differences in performance between children of differing reading ability could be attributed to initial naming speed deficits.

Comparisons of follow-up results in the RB and CRP conditions

The rates were higher for 74.4% of the follow-up RESAA probes in the RB condition than in the CRP condition. These findings showed that building higher rates of see/say phonemes ensured greater retention of rates on most of the RESAA measures three months after the intervention was completed. Other researchers have reported greater skill retention when higher, rather than lower, response rates are attained during acquisition (e.g., Shirley & Pennypacker, 1994). However, studies have not assessed the retention of rates on all of the RESAA measures after a significant interval of no practice. Thus, the current study has provided a more comprehensive investigation of retention rates for each of the RESAA outcomes after a significant period of three months.

Comparison of quantities of reinforcement in each condition

Doughty, Chase and O'Shields (2004) highlighted the lack of control for reinforcement effects in most studies of rate-building procedures. Therefore, improved performance cannot be attributed solely to the rate-building exercises in these studies, as increased reinforcement during rate-building may have also accounted for the improvements. The current study counted the quantity of contingent reinforcement in each condition. All but one of the individuals in Study 2 received more reinforcement in the CRP condition than in the RB condition. The student who received more reinforcement in the RB condition, obtained only one more instance of reinforcement in this condition than in the CRP condition. Thus, the difference was negligible. These findings demonstrated that the improved performances of the children in the RB condition during training and on most of the RESAA probes and follow-up tests were the consequence of increases in response speeds and were not attributable to greater quantities of reinforcement in the RB condition.

Summary

The findings of the current study showed that children who were classified as very poor, poor and average readers according to scores on the TERA-3 were able to build similar see/say phoneme rates during training. Thus, the attainment of increased see/say phoneme rates was not affected by the reading ability of the children as assessed on a standardized measure.

Although similar training rates were attained by the three reading ability groups, the very poor group performed at consistently lower rates on the RESAA measures than the other two groups. The group of children classified as of average reading ability demonstrated consistently superior performance rates on the RESAA measures than the other two groups. Thus, the rates of performance on the RESAA measures were affected by the children’s levels of reading ability. Therefore, it was concluded that the attainment of a particular see/say phoneme rate did not predict the same levels of performance on the RESAA measures across individuals. The implication from this study was that children of lower reading ability would possibly have to build higher rates of responding than children of higher reading ability to ensure similar levels of performance on the RESAA measures.

Comparisons of individual RESAA data also indicated that the achievement of a particular see/say phoneme rate by a child did not predict the same levels of performance on each RESAA measure for that child. Rather, evidence of skill retention, endurance and stability were generally observed before skill application, which often occurred before skill adduction.

The controls for practice effects and the investigation of quantities of reinforcement in each condition overcame the common limitation existing in most studies of rate-based procedures. The findings showed that speeded repeated practice was more effective in increasing see/say phoneme rates than constrained-repeated practice when the quantities of practice were equal and with similar or smaller quantities of reinforcement in the RB condition. The results also demonstrated that the superior rates on most of the RESAA probes and on the follow-up tests were attributable to improved see/say phoneme rates and were not produced by greater quantities of practice or reinforcement in the RB condition compared to in the CRP condition. Furthermore, these results highlighted the importance and the sensitivity of rate-based measures of performance compared to percentage correct measures. Rate of response provided a superior means of comparing the effectiveness and efficiency of the RB and CRP procedures as training techniques. Response rates were also a better predictor of the RESAA outcomes than percentage correct scores.

Adduction was measured for a one-channel and a two-channel cross. The results of Study 2 did not support the claim that adduction was greater across one learning channel than two at specific rate aims. However, a possible confounding of the results was the greater complexity of the Adduction 1 task compared to the Adduction 2 task used to measure adduction across learning channels. The use of learning channel analysis did, however, provide a useful tool for describing the learning and assessment tasks in unambiguous terms, for clearly differentiating application and adduction tasks in terms of trained and untrained learning channels, and for planning and describing the measurement of adduction in terms of the similarities or differences of the assessment tasks compared to the training task.

Implications for future research

Future research is essential to explore questions that have arisen from Study 2. The effects of higher training rates than those achieved by the participants in this study on the RESAA outcomes, and particularly on the application and adduction outcomes, are required. These may delineate clearer guidelines for setting rate aims that are most likely to ensure functional achievement on RESAA measures and, thus, specify fluent performance.

Some possible limitations in the adduction measures in the current research were noted. Additional studies should possibly investigate alternative adduction tests and further investigate the utility of learning-channel analysis. Such studies are important for practitioners as they may highlight implications for teaching through different learning channels and influence decisions about instructional procedures that will facilitate the greatest level of adduction, thereby possibly reducing the time and effort required to teach specific composite skills.

The systematic analysis of the effects of specific training rates on all of the RESAA outcomes has been investigated in very few studies. Similarly, examination of the long-term retention of rates on all of the RESAA measures after a significant period of no practice has also been neglected in research investigating response rate-building. Replication of the present research is warranted to allow comparisons to be drawn between present and future findings of the specific effects of different training rates on each of the RESAA measures. These may contribute to advancements in the definitions of the RESAA criteria themselves with progress towards a uniformly defined and functional classification of fluency.

CHAPTER 10

GENERAL DISCUSSION FOR STUDIES (1) AND (2)

The results of Studies 1 and 2 were discussed individually in Chapters 6 and 9. This chapter presents a general discussion of the findings of both studies and examines the theoretical and practical considerations that relate to these results. First, the general conclusions drawn from the two studies are delineated and discussed. Then follows a discussion of hypotheses and theoretical implications that relate to the findings. Finally their implications for practitioners and for future research are presented.

The investigation of practice and reinforcement effects in both studies provided strong empirical evidence that the results were attributable to the effects of increased response rates rather than the consequence of increased practice or reinforcement in a particular condition. Analysis of practice and reinforcement effects in the current research responded to recommendations in the literature and overcame the two common limitations of most studies of rate-building for fluency (Doughty, Chase & O'Shields, 2004; Kuhn & Stahl, 2003).

In Study 1 the research findings indicated that for the Year 2 children and two pre-primary children, even with smaller quantities of practice and reinforcement, simultaneous training of accuracy and rate produced higher see/say phoneme rates and concurrently higher RESAA rates than training accuracy to 100% and then building rate in stages. A stage process, whereby accuracy was trained to 100% before rate-building commenced was identified as a slightly more efficient means of increasing see/say phoneme rates and RESAA rates than simultaneously training accuracy and rate for only five of the seven pre-primary children. Even here, the differences between the rates in the two conditions were minimal, which suggested that the RBAAT training procedures were only marginally more efficient than the RB methods for the younger students. It was concluded in Study 1, that regardless of the most efficient means of increasing training rates, higher training rates generally produced higher RESAA rates on the immediate post-tests and follow-up tests three months after the completion of the intervention.

The results of Study 2 demonstrated that the superior training rates in the RB condition produced concurrently higher RESAA rates than the same quantity of constrained-rate repeated practice. Moreover, greater quantities of reinforcement were provided in the CRP condition, which indicated that the superior results in the RB condition were not the consequence of increased reinforcement. Thus, response speed was again identified as the critical factor influencing superior improvements on the RESAA measures when the effects of practice and reinforcement were controlled.

In conclusion, in both Studies 1 and 2, increases in training rates generally produced increases in RESAA rates. Moreover, the higher the rates each child achieved, the higher the rates they achieved on most of the RESAA probes. The results of these studies also provided empirically validated responses to two questions posed by Binder (2004). First, Binder (2004) proposed that research should investigate whether response rates are a better predictor of the learning outcomes than percentage correct, regardless of whether these rates are trained in controlled-rate trials, in free-rate trials, or through a combination of these procedures. Self-paced practice was utilized in the RB conditions of both studies in the current research. Controlled-trials practice comprised the CRP training procedure in Study 2, and the children learned the phonemes through a combination of self-paced and controlled-trials practice in the RBAAT condition of Study 1. The findings provided strong evidence that it is the rate of more freely-emitted responding that better predicts the RESAA outcomes regardless of the method by which the rate is produced. Second, Binder (2004) proposed research should investigate whether response rate measures provide more information than percentage correct scores. The results of both studies demonstrated the greater sensitivity of rate measures compared to percentage correct scores under controlled experimental conditions. The use of only percentage correct measures would not have allowed a means of comparison beyond 100% accuracy between the effects of the two training procedures in each study on training rates, or the differential effects of these rates on the children's performances on the RESAA measures.

Study 2 contributed to the literature by measuring RESAA outcomes at precisely defined, incremental rate aims. Such measures have not been found in any other research to date. Precise measurement of the RESAA outcomes at incremental target rates allowed the comparison of the effects of a number of specific training rates on different outcomes as the rates developed. This has not been possible in studies that have only used pre-intervention and post-intervention measures. The use of only pre-intervention and post-intervention data can result in incremental changes in behaviour and trends that occur between these measures being missed. In contrast to this method, the design of Study 2 was highly sensitive to changes in data and provided a detailed account of the effects of the attainment of systematically increasing response rates on RESAA rates. Moreover, see/say training rates and rates on the RESAA measures were also continuously measured under conditions that allowed freer-responding in the CRP condition. The repeated measurement of free-responding in both conditions in Study 2 allowed the effects of the <u>rate of response</u> on the RESAA outcomes to be analysed, rather than only the effects of training under free-rate and constrained-rate conditions to be assessed. The design provided every opportunity for rate "warm-ups" on <u>both</u> sets of phonemes when measures of outcomes were taken and thus, if anything, was a positive bias for the CRP condition rather than the RB condition.

The research has shown that children of different ages and different levels of reading ability can build the speed of see/say phonemes. Whilst the Year 2 children in Study 1 were able to build higher training rates in the same time period than the younger pre-primary children, participants with differing reading ability in Study 2 were able to build comparable training rates in an equal period of time. Thus, age was a factor that directly influenced the training rates attained by the children in Study 1. However, the level of reading ability of the children in Study 2, as categorized by scores on the TERA-3, was not a factor that affected the training rates achieved by these participants.

Although the attainment of <u>training</u> rates was not greatly influenced by the levels of reading ability in Study 2, the level of reading ability of the children was shown to be a significant factor affecting the achievement of <u>RESAA</u> rates. Distinct differences in performance rates were evident on the RESAA probes between groups. Furthermore, the disparities in RESAA rates between groups became increasingly larger for the application and adduction outcomes. It was concluded that a particular training rate did not predict the same level of performance on the RESAA measures for all participants. Rather, the implication was that the children classified as of lower reading ability would likely have to build higher rates to ensure the same levels of performance on the RESAA probes than the children categorized as average ability readers.

Another finding in the research was that a specific rate aim did not ensure the same level of performance on each RESAA measure for a particular child. Rather, component rates on the retention, endurance and stability probes generally increased more rapidly at lower rate aims than composite rates on the application and adduction probes. In addition, evidence of application generally occurred before skill adduction. Therefore, the RESAA outcomes appeared to depict essentially three levels of performance outcomes as progressively higher rates were generally required to ensure skill retention, endurance and stability (RES), application (A), and finally adduction (A).

Although age was a factor affecting the attainment of training rates within a specific time period, it was the speed of responding during training that affected the increases in RESAA rates. Comparisons of the findings of Studies 1 and 2 supported this hypothesis. In Study 1 the older Year 2 children demonstrated higher RESAA rates than the younger pre-primary children. These results in isolation could have suggested that the age of the participants affected the improved RESAA rates. However, Study 2 involved children of similar ages and it was found that higher training rates generally produced higher RESAA rates. Therefore, it was more likely that the superior RESAA rates of the Year 2 children in Study 1, compared to the pre-primary RESAA rates, were the result of the higher training rates achieved by the Year 2 students rather than being solely attributable to the age of the children.

The investigation of adduction through learning channel analysis supported the hypothesis that a greater level of adduction would be evident for a one-channel cross than for a two channel cross in Study 1 but the results of Study 2 did not support this finding. Possible limitations of the Adduction 1 tests in each study may have confounded these results. It was suggested that the hear pseudowords/say phonemes Adduction 1 tests in Study 1 were perhaps more reliant on phonemic awareness than the ability to see/say phonemes. In Study 2, the Adduction 1 tests were possibly more difficult than the Adduction 2 tests, due to the visual prompts available in the Adduction 2 tests, and therefore the lower rates on the former tests may have been attributable to differences in task complexity rather than to the number of learning channels that were crossed. Moreover, the results imply that an analysis and measurement of required pre-skills is necessary to predict adduction outcomes, rather than only the numbers of channel crosses. For example, the speeds at which the participants said letter names may also have affected the rates on the Adduction 1 tests. There is a need for more controlled studies into learning channel analysis and the effects of increased training rates on the levels of adduction for one-channel and two-channel crosses.

Error rates were not specifically targeted in the intervention in either study. Although an error correction procedure was used to improve accuracy during the rate-building exercises in both studies, only increases in correct rates were reinforced and the rate aims that were set for the participants comprised descriptions of correct rate aims only. Thus, it was found that without specifically targeting incorrect rates, reductions in these rates occurred as correct rates increased.

Theoretical explanations

The increases in correct training rates in the present studies were likely attributable, in part, to the effects of differential reinforcement. Two forms of differential reinforcement interacted with the operants in both studies. Differential reinforcement to establish stimulus control was involved in discrimination training. That is, accurate see/say phoneme responses were occasioned in the presence of the discriminative stimuli by the presentation of reinforcers for correct responses and the withholding of reinforcers for incorrect responses. As appropriate responses to the printed letters or letter-pairs were reinforced over time, these responses were strengthened in the presence of the discriminative stimuli and accurate discrimination occurred. Inappropriate responses to the letters or letter-pairs did not result in the presentation of reinforcers and thus, incorrect responses decreased through the process of extinction. That is, these responses were not selected by environmental contingencies and the frequency of these responses in the presence of the discriminative stimuli decreased. However, an error correction procedure was used throughout the rate-building exercises and some effects of demonstration (i.e., during the DI procedure used to correct errors) would also have reduced errors.

The finding that some participants' incorrect rates initially showed rapid increases when timed performance was introduced is characteristic of the process of extinction. Increases in the rate of behaviour often occur before a significant reduction occurs, as a reinforcement history has taught the learner that a particular response will result in a reinforcer (Alberto & Troutman, 1990). Examples of such reinforcement histories of the participants in the current studies were revealed when many of the incorrect responses to the printed single phonemes and digraphs consisted of the children saying words instead of sounds or individual phonemes instead of the digraph sounds, or even saying numbers. It was likely the children had previously been reinforced for such responses when shown printed material in the past.

A second form of differential reinforcement for shaping was involved in increasing response rates in both studies. During rate-building, reinforcement was contingent upon the demonstration of successively higher accurate see/say phoneme speeds and reinforcers were withheld when the participants did not attain specific speeds. Differential reinforcement thus shaped the speed of accurate see/say responses through successive approximations to high accurate see/say rates.

In Study 1, differential reinforcement increased stimulus control and differential reinforcement for shaping occurred separately in two stages in the RBAAT condition. Accurate discrimination was first reinforced in the accuracy training stage and then successive increases in response speeds were reinforced in the rate-building stage. In contrast, the two forms of differential reinforcement occurred simultaneously in the RB condition as the children concurrently learned to discriminate and increase correct responses to successively higher rates. Although both sets of procedures produced increases in correct training rates, superior training rates were achieved by all of the Year 2 children and two of the pre-primary children in the RB condition compared to in the RBAAT condition within the same time period.

The greater efficiency of the RB training procedures in increasing training rates to levels that were higher than in the RBAAT condition for many of the children in Study 1 over an equal time period may have related to the pace at which differential reinforcement could operate in the two conditions. Basing their analysis on the selectionist model proposed by Skinner, Vargas and Vargas (1991) emphasized that the higher the response rates, the more opportunities there are for the selective mechanisms in the environment to work and thus shaping occurs more quickly. Such an analysis could explain the findings in Study 1. Only one form of differential reinforcement was initially functional in the RBAAT condition, as reinforcement was contingent upon correct responses only in the accuracy training stage and presentation of the discriminative stimuli occurred in slow-paced discrete trials. Only after the children attained 100% accuracy on two consecutive trials did reinforcement become contingent upon building higher response rates and the process of shaping speed and rate commenced.

In contrast, the children were immediately involved in rate-building exercises in the RB condition in which reinforcement was contingent upon the achievement of successively higher accurate see/say rates, and in which the children self-presented and self-paced the discriminative stimuli. Thus, both forms of differential reinforcement occurred immediately in the RB condition and no ceilings were placed on the number of stimulus presentations or on the speed of participant responses during each timing. Therefore, there were initially more immediate opportunities for required operants to interact with and be selected by contingencies in the environment in the RB condition than in the RBAAT condition, which may have facilitated quicker discrimination and shaping within an equal time period. Although more practice and reinforcement was provided in the RBAAT condition, higher training rates were produced in the RB condition within the same time period because of the greater quantity of immediate opportunities for both forms of differential reinforcement to select and shape behaviour. Thus, as differential reinforcement instantaneously influenced both discrimination and shaping of the behaviour in the RB condition, higher response rates were conditioned more quickly than in the RBAAT condition in which behavioural shaping did not occur until after accurate discrimination was achieved.

The finding in Study 2 that higher training rates were produced by speeded repeated practice in the RB condition than the same amount of constrained repeated practice in the CRP condition can also be related to the pace at which differential reinforcement could influence the operants in the two conditions. In the CRP condition reinforcement was contingent only on accurate performance, the presentation of discriminative stimuli was not learner-controlled, the pace of presentation of the discriminative stimuli was slow and the children were not able to build response rates above 20 per minute. In contrast, in the RB condition differential reinforcement was contingent upon both accurate responses and increased speeds of responding. In addition, the discriminant stimuli were learner-controlled, learner-paced and there were no external restrictions on the rate of responses. Thus, in the CRP condition the children simply established correct responses through discrimination training and then repeatedly practiced these responses on slow overlearning trials. The constrained practice did result in increases in see/say training rates on the free-rate measures. However, higher training rates were likely produced in the RB condition because of the immediate opportunities for discrimination and shaping to develop through differential reinforcement. When discrimination had developed, the reinforcement of successively higher training rates continued to shape the behaviour, a process that was not applied in the constrained repeated practice of the digraphs in the CRP condition. Therefore, there was not the same degree of selective mechanisms at work to increase training rates in the CRP condition as there was in the RB condition.

An analysis of the environmental conditions under which the operants were able to function also provides an explanation for the superior training rates in the RB condition in each study. Lindsley (1996a) discussed the “four free-operant freedoms” which included the freedom to self-present and self-pace stimuli, the freedom to form responses, the freedom to repeat responses and the freedom to speed. These “freedoms” were immediately available to the children in the RB conditions of Studies 1 and 2. Thus, there were no restrictions placed on training rates in the RB conditions and the quantity and pace of interactions of operants with the environment was entirely under the control of the learners. Therefore, there were no restrictions placed on the pace at which differential reinforcement could act upon the operants and condition responses. Conversely, in the RBAAT condition in Study 1 the children were only involved in free-operant learning after a particular interval of learning under constrained-operant conditions. In the CRP condition in Study 2, the children did not learn under free-operant conditions at all. Therefore, the pace at which differential reinforcement could condition the operants was restricted.

The question then arises: why did most of the pre-primary individuals in Study 1 demonstrated superior training rates in the RBAAT condition compared to in the RB condition? If there were more optimum conditions for the process of differential reinforcement to affect greater increases in training rates in the RB condition for all of the Year 2 children and two of the pre-primary participants, why did five of the pre-primary individuals demonstrate slightly higher see/say training rates in the RBAAT condition than in the RB condition? The answer to this question is possibly underscored by the effects of generativity or cumulative frequency of component behaviours, an important principle on which the Generative Instruction model emphasized by Johnson and Layng (1992; 1994) is based.

The analysis of component and composite behaviour is fundamental to the concept of Generative Instruction (Johnson & Layng, 1994). The rudimentary principle underlying Generative Instruction is that the higher the rates of component tool skills, the greater the acceleration of the more complex composite behaviours of which the components are a part (Binder, 1988; 1996; Leach, 1996; Johnson & Layng, 1992; 1994; 1996; Dougherty & Johnston, 1996; Freeman & Haughton, 1993; Haughton, 1972; Starlin, 1972). When component skills are established they are made available to the environment and, thus, new contingencies can select certain components that can combine to form novel and untaught composite performances (Johnson & Layng, 1992). These cumulative effects have been termed “contingency adduction” and explain the reported “curriculum leaps” made by students at Morningside Academy (Johnson & Layng, 1992; 1994). These observations have led Johnson & Layng (1994; 1996) to reason that learning actually becomes easier as learning material becomes more complex and that intensive instruction is only necessary in the initial stages of learning.

Component-composite analysis can be applied to explain the difference in the efficiency of the RB and RBAAT training procedures for increasing the training rates of the pre-primary and Year 2 children in Study 1. In Chapter 6, it was suggested that the younger pre-primary children were unlikely to be equipped with the same levels of pre-reading skills as the older Year 2 children. The Year 2 children were likely to have possessed more reading skills, such as higher levels of phonemic awareness, alphabet awareness, sound-symbol correspondences, and the ability to discriminate “same” and “different” phonemes. Thus, the Year 2 children were likely to have had a greater number of component skills available for selection by environmental contingencies, and cumulative effects may have eased the acquisition of the see/say digraph skill. That is, the adduction of component skills may have facilitated the acquisition of the composite performance. In contrast, if the pre-primary children were not equipped with the required components, then there would be a smaller possibility that contingencies in the environment would select behaviours and that components would adduce. Cumulative effects would not function and the children may have required more intense instructional support to achieve accurate discrimination than the Year 2 students. Thus, the immediate focus on accuracy and rate in the RB condition may simply have placed more demands on the younger pre-primary children. Research has shown that phonics training is less effective when children have less phonemic awareness (Juel, 1988; Stahl, 1992; Griffith & Olson, 1992; Juel, 1988; Yopp, 1995).

The concurrent increases in RESAA rates as training rates improved in both conditions of Studies 1 and 2 can also be related to increases in the number of opportunities for differential reinforcement to influence stimulus control and the shaping of the component skills targeted for intervention. Each time a discriminative stimulus was presented and an appropriate response was reinforced, that behaviour was strengthened in the presence of that particular stimulus. Therefore, the more frequent the interaction of these operants with reinforcing contingencies in the environment, the more these component behaviours became firmly established in the learners' repertoires. Skinner maintained that the advantage of response rate as a measure lay in its usefulness in predicting the probability of a response occurring (Skinner, 1953; Skinner & Epstein, 1982). That is, rate provides an indication of the strength of the response in relation to particular discriminative stimuli (Skinner & Epstein, 1982). As a consequence of increased response strength, as indicated by increased training rates, the component skills were more likely to be retained, to endure over longer performance intervals and to be stable in the presence of distraction. The discriminative stimuli were also more likely to occasion the appropriate responses in the context of applied tasks as training rates increased and conditioning of the behaviour strengthened. As the participants' ability to retain and functionally use the component skills increased, the availability of these operants to be selected by environmental contingencies and to combine and be used in conjunction with other component skills (that is, the process of adduction) also increased.

Although increases in RESAA rates were evident in both conditions, in Study 2 superior RESAA rates were generally more frequent in the RB condition than in the CRP condition even though the number of practice repetitions was equal. The question now presented is: why did the superior RB training rates produce superior performance on the RESAA probes even though the number of opportunities for the operants to interact with environmental contingencies was equal?

Speed of practice rather than the quantity of practice was highlighted as the critical factor influencing superior RESAA rates in Study 2. These findings may be explained in terms of response latency. Latency refers to the time that elapses between the presentation of a stimulus and the student beginning to perform a behaviour or response (Alberto & Troutman, 1990). If the participants were able to attain higher see/say training rates in the RB condition than in the CRP condition on free-rate probes, during which conditions were identical, then it is reasonable to assume that the time taken to form a response after self-presenting a stimulus was shorter in the RB condition than in the CRP condition. That is, the reinforcement of fast, accurate responses in the RB condition likely trained shorter response latencies (i.e., further increased the strength of stimulus-response associations) in the RB condition compared to in the CRP condition. If response latencies were shorter during training, similar stimuli presented under slightly different conditions, as during RESAA assessments, would also be likely to occasion faster responses. As a result the participants would be able to respond at a quicker pace on the one-minute timings in the RB condition and, thus, attain higher rates. In the CRP condition, higher response latencies would place restrictions of the number of phonemes that could be read in one minute.

The overall improved long-term retention rates on the RESAA follow-up probes in the RB condition for the Year 2 children, and in the RBAAT condition for the pre-primary group in Study 1, demonstrated that higher training rates increased the likelihood that the component skills would be performed at higher rates three months after the termination of the interventions. These findings again implied that higher training rates were an indication of greater response strength. That is, higher training rates suggested improved levels of operant conditioning which increased the likelihood that the discriminative stimuli would occasion the same responses three months after a period of no practice. Similar assumptions were derived from the results of the Study 2 follow-up probes. Overall, see/say rates were higher in the RB condition than in the CRP condition on these measures. As training rates were higher in the RB condition, the component skill was more firmly established in the children's repertoires, and thus there was a greater probability that these discriminative stimuli would occasion the same responses three months later.

The findings in Study 2 that indicated that similar training rates did not predict the same levels of performance on the RESAA measures across participants can also be analysed in terms of the strength of associations between the discriminative stimuli and appropriate responses. The results showed that the component see/say digraph skill was more functional for some children than for others at similar training rates. The results also indicated that some children were able to cope with the greater demands of increased task complexity, as in the application and adduction activities, than others at similar training rates. These findings suggest that for some of the children certain strengths of stimulus-response associations, indicated by particular response rates, were possibly sufficient for the skill to be functional for that child. For other children the component skill would have to be built to higher training rates to ensure the associations between the discriminative stimuli and responses were sufficient in strength for the skill to be useful. The differences in participant performance of the three reading ability groups also emphasized the necessity of collecting and basing instructional decisions on individual student data. The fact that the children categorized in the three groups demonstrated similar increases in training rates, may have superficially implied the children displayed similar levels of achievement. However, as has been shown, measurement on the RESAA probes indicated far inferior rates were attained by the very poor group than the average group. Thus, it was not possible to specify one particular rate that would ensure similar performance on the RESAA measures for each individual.

Findings in Study 2 also indicated that a particular training rate did not ensure the same level of performance on each of the RESAA measures for an individual child. These results may be explained in terms of the response requirements to achieve these outcomes. The retention, endurance and stability tests required only component skill performance. In contrast, the application and adduction tests necessitated composite skill performances for which the component skill trained during the intervention was a part. Therefore, higher rates of the component see/say phonemes skill were required to complete the more complex application and adduction tasks. At higher training rates the component skills would likely have undergone a greater degree of operant-conditioning and, thus, there was likely an increased probability that a particular discriminative stimulus would occasion a desirable response within the context of the composite application and adduction tasks.

The finding that indications of improved performance on the RESAA measures occurred at different training rates for specific outcomes underlines the importance of probing performance for <u>all</u> of the measures to inform decisions on the attainment of fluent performance standards. Whilst a particular training rate may have ensured comparable performance rates on the retention, endurance and stability probes, the same rate did not ensure the same level of performance on the application and adduction measures. Perhaps these findings indicate that a particular training rate may have ensured the component skills were functional in component performances but did not ensure they were useful in composite performances. However, this again relates to the definitions of application and adduction and the criteria by which "achievement" of these outcomes is measured. Binder (2004) aimed to clarify the definition of application according to the precision teaching and fluency literature. He referred to a reference by Fabrizio and Moores (2003) and stated that,

> "precision teachers are looking for application when they check to see if learners readily combine components into composites….during the instruction and practice of behaviour composites once they have achieved a specific range of count-per-minute responding on those components" (Binder, 2004; p. 283).

Thus, Binder (2004) suggested that it is not to be expected that the composite skill rates on application tasks will be similar to the trained component skill rates when initially probed. Rather, the composite skill may be most efficiently practiced to higher rates when facilitated by training to sufficiently high rates of component skills. Therefore, more modest evidence of the combination of component skills within the context of composite skills appears a sufficient criterion for the "achievement" of the application and adduction outcomes to be judged. This view is supported when component-composite analysis and the effects of generative instruction are taken into consideration. The theory of component-composite relations is based on the concept of a hierarchy of skills. Within this hierarchy, one skill could be a composite of other components but the same skill could also be a component for a higher-level composite performance. For example, oral spelling in Study 2 was a composite behaviour that relied on the see/say phonemes skill as a component. However, the ability to spell a word is also a component skill necessary for the more complex composite task of writing passages. Thus, it may be appropriate to consider that application and adduction outcomes are achieved after the demonstration of component skill use within application and adduction tasks, even though these performance rates may be low, because the composite skills involved in these tasks would then, in practice, be trained to high rates as components for even higher level composite performances. However, questions still remain concerning how the "adequate demonstration" of application and adduction is to be determined. For example, is one demonstration of applied skill use sufficient?

Implications for practitioners

An important implication drawn from the research concerns the arrangement of environmental conditions to optimally enhance learning. In both studies superior training rates generally produced higher RESAA rates and RESAA follow-up rates. Many researchers have lamented the lack of fluency instruction in most modern classrooms (White & Brewer, 1992; Binder, 1996; Shirley & Pennypacker, 1994; Johnson & Layng, 1994; Worthy & Broaddus, 2002; Chard, Vaughn & Tyler, 2002). It is the unfortunate circumstance that most learning in contemporary schools <u>at best</u>

occurs under constrained-operant conditions in programs that centre on establishing skills to accuracy, and they provide little, if any opportunity for these skills to become more fluent. Rate-building is very rarely incorporated in reading programs in contemporary schooling (Reutzel & Hollingsworth, 1993; White & Brewer, 1992; Worthy & Broaddus, 2002). Thus, reading achievements of many children are actually restricted in modern classrooms; the antithesis of stated educational goals.

When the effects of cumulative deficits are taken into consideration, the negative influence of a lack of provision for rate-building is highlighted further. Binder (1996) noted that generativity results from cumulative frequency and that cumulative deficits occur when component skills are not developed to fluent standards. In essence, the learning of more complex composite skills is burdened by dysfluent component skills and, as the performance complexity increases, so too does the burden of dysfluent component skills. Thus, it is not surprising that the children identified as poor readers at the beginning of Year 1 typically continue to be identified as poor readers as they progress through the primary grades (Adams, 1990). Skills for all children need to be trained not only to accuracy but to rates that are sufficiently high to ensure performance is fluent. Some teachers have voiced concern that there is insufficient time available for students to practice skills to high rates (Johnson & Layng, 1994). However, as Johnson and Layng (1994) argue, time is already wasted in reteaching skills that have been forgotten, and there are few, if any opportunities in modern classrooms for a majority of children to make the “curriculum leaps” produced when component skills are trained to high rates.

A second implication follows from the findings in Study 2 that the children who were categorized as very poor readers demonstrated much poorer performance on the

RESAA measures than the children classified as average readers even though component skill training rates were similar. Some children have to build higher training rates than others for a component skill to have comparable functional utility for individuals. As it is highly probable that many children will not attain high rates of component reading skills in the primary grades, the children who need to build the highest rates of component skills are at a far greater disadvantage than the children who can manage more complex tasks equipped with lower rates of component skills. Those children who need to build higher training rates to ensure the same learning outcomes are the individuals who will most probably encounter significant difficulties in learning to read later and are likely to be those children classified as persistent "poor readers". Thus, perhaps the literature that has shown children with "reading disabilities" often name letters and sounds more slowly than average readers simply highlights that these children have been classified with a reading disability because they continue to have low rates of component skills and have not been given the opportunity to increase them to functional levels.

Binder (2004) cautions against the use of the term "high response rates" because this implies rates that are "out of the ordinary, extreme, or unusual" (p. 282). He prefers the use of the term "normal ranges of response rate" (Binder, 2004; p. 282). Whilst this point is important (and the present researcher is not implying the attainment of extraordinary rates of component skills is necessary) the findings in Study 2 suggest that the term "normal ranges of response rate" may be misleading. If some children have to build higher response rates than other to ensure the same learning outcomes, then there are no "normal" ranges as such. Therefore, perhaps Binder's (2004) use of the term "normal ranges of response rate" should be replaced by the term "functional ranges of response rates" that comprise rates that predict or optimize the RESAA outcomes.

The importance of rate as a measure of student performance and achievement was underscored in both studies. In Study 1, the participants reached the accuracy criterion in the RBAAT condition when they could read each phoneme in the set with 100% accuracy on two consecutive trails. Although all of the participants attained the accuracy criterion, it was common to observe rapid increases in incorrect rates and the demonstration of low correct rates when timed performance was introduced. Similarly, in the CRP condition of Study 2, data showed that although some participants were responding with 100% accuracy on each set of discrete trials, the free-rate probes indicated relatively high incorrect rates and low correct rates on some timings. These results indicated that the percentage scores did not reveal much about the strength and quality of their learning. Furthermore, although the children could demonstrate 100% accuracy in the RBAAT and CRP conditions, they generally showed lower rates on the RESAA probes and follow-up tests than in the RB conditions in which response rates were higher. These results showed that, although the children could demonstrate highly accurate responses on some trials, the skill was not as functional to the learner when response rates were insufficiently high. This finding was only identified through the use of rate as a measure of student performance.

The utility of learning-channel analysis for researchers and practitioners was highlighted in this research. Binder (2004) clarified that in application tasks the composites are trained, whereas adduction refers to the demonstration of the composites without specific training. Binder (2004) described adduction as a "…special case of application in which behaviour components at certain response rates combine with no explicit training on the composites" (p. 283). According to these definitions, the application tasks in the current studies might be perceived as adduction tasks as the measures probed the use of the component see/say phonemes skill in the context of the composite application tasks which were as a whole activity <u>not trained</u>. However, learning-channels provided an alternative means of analysing the application and adduction tasks utilized here. The component see/say phonemes skill was trained in the "see" and "say" channels. The Application 1 task was an oral segmentation task, and required the children to see/say phonemes within the context of a pseudoword. The Application 2 task was an oral blending task, and required the participants to see/say phonemes to produce the pseudowords. Both the component training and the composite application tasks required see/say phonemes responses. Thus, the component skill was trained through the see/say learning channels and the application tasks probed the use of the skill in composites tasks through the <u>trained</u> see/say channels. In contrast, the adduction tests probed the use of the component skill on composite tasks involving <u>untrained</u> learning channels. The hear/say Adduction 1 and the hear/mark Adduction 2 probes assessed the use of the component skill within the composite tasks when one learning channel and two learning channels had <u>not</u> been specifically trained. Thus, the use of learning channel analysis allowed clearly defined application and adduction outcomes to be probed and the measures employed in this research are considered to have been very stringent assessments of application and adduction that might be considered as alternatives for practice and in future research.

Overall the studies have provided implications for the operationalization of fluency in terms of specifying response rates that predict the outcomes depicted in the RESAA criteria. Whilst it has been shown that particular component training rates did predict similar rates on measures of retention, endurance and stability for certain individuals, it has also been shown that these same component training rates do not predict the same levels of performance on measures of application and adduction. However, specific component training rates did predict some evidence of application and adduction for most individuals. Thus, evidence of application and adduction may imply a learner is "ready" to advance to the next skill in a learning sequence. If this learner encounters difficulty in increasing the rates of the new composite skill, the implication would be that fluent component skills were not achieved, which would signal to the teacher that this learner required further rate building of the previous component skills. Johnson and Layng (1992) describe such decisions to step back in the curriculum in their account of the Model of Generative Instruction used at Morningside Academy. In this way, the research has contributed to clarifying the operational definition of fluency and has shown that a component skill may be considered fluent when component rates on measures of retention, endurance and stability are maintained <u>at the same rates</u> as during training and when some <u>evidence</u> of application and adduction is observed. However, defining "evidence" is still a matter of concern and needs further controlled investigation.

Most of the children in the two studies showed decreases in correct rates on the follow-up tests three months later. These findings are consistent with other reports of studies investigating the effects of rate-building on long-term retention (Semb, Ellis & Araujo, 1993; Bucklin, Dickinson & Brethower, 2000; Omrod & Spivey, 1990). Such decreases may have occurred because the children's training rates were not sufficiently high to ensure retention over longer periods, given that they received no formal timed practice of the phonemes in the meantime. Thus, an implication for practitioners may be that higher training rates than were attained in this study are necessary to guarantee higher retention rates over extended periods of no practice. However, Lindsley (1992b) reported that Precision Teaching data always show sizable regressions after periods of no practice, such as holidays. Thus, the inference is that children may have to again practise skills that were considered to be demonstrated at sufficiently high rates after longer periods of no practice. Would such regressions indicate that the skill was not fluent? More likely, the performance rates of this skill may show very rapid improvements up to previous rates when the skill is briefly practised again, indicating that the skill simply needed rehearsal.

Directions for future research

Future studies may investigate the effects on retention of RESAA rates after three months of no practice when higher training rates are attained in the intervention phase. Perhaps the higher training rates would ensure similar performance rates on the RESAA measures three months after the termination of the intervention. Alternately, such research might support Lindsley's (1992b) assertion that regressions in rates are generally evident after periods of no practice. In this instance, prospective research may investigate whether rates rapidly return to training rate levels with very brief intervention. The research may examine whether longer intervals of no practice necessitate greater quantities of rehearsal for rates to return to training rate levels. Answers to these questions will influence the concept of fluency. For example, can fluency be lost, or will a skill that is truly fluent always be retained? Does a rapid return to training rates with minimal intervention after a period of no practice indicate the skill was fluent but that the learner was simply "out of practice" in using it? Does this suggest that fluency can decline and then increase again and, thus, are there different levels of fluency? Or is a skill either fluent or non-fluent? These issues need further clarification.

The current research indicated that there was a necessity to clarify what constitutes “achievement” of the RESAA outcomes to indicate when a skill reaches fluent performance standards. The question particularly pertained to the application and adduction outcomes. At around the 105-125 per minute and 126-146 per minute rate aims in Study 2, accelerated increases in application and adduction rates began to emerge for some children. Unfortunately, practical and time constraints limited a return to investigate higher training rates. There may be larger spontaneous increases in application and adduction rates than were observed in the present studies because training rates here were not sufficiently high to affect such improvements.

The investigation of adduction across one and two learning channels was confounded in the current research project. More research is needed into this promising field of study. If it can be shown that learning in one channel is independent of learning in other channels, as Lindsley (1994; 1998) maintained, implications for teaching through multiple learning channels to enhance learning will be highlighted. Additional research might demonstrate the utility of learning channel analysis in probing for application and adduction that will more clearly and operationally define these concepts for practitioners.

Future studies into the effects of increased response rates on the RESAA measures may include more precise measures of stability. Binder (2004) noted that the original use of the term “distracability” related to the notion of competing stimulus control. He suggested that “…behaviour at rates closer to normal competent ranges (i.e., of greater response strength) might compete more effectively with potentially conflicting stimulus control at lower rates or response strength" (Binder, 2004; p. 284). Binder (2004) described pilot studies in which the participants heard numbers read through earphones whilst they attempted to provide oral responses to math problems. He noted that "ambient noise" (p. 284) was beginning to be used to assess response stability by precision teachers. In retrospect, the stability measures in the current research could possibly have involved the use of phonemes read through headphones whilst the children were engaged in the see/say exercises.

More studies into the effects of increased rates in predicting the RESAA outcomes that are longitudinal in nature are necessary. As Perfetti (1986) maintained, many studies have shown only superficial increases in speed and there is a lack of reports about readers whose reading speeds have been permanently increased. The lack of such evidence most likely arises from the fact that many empirical studies have been conducted over relatively short periods of time. Thus, learners have possibly not had the opportunity to build sufficiently high rates for these speeds to be retained, or made relatively permanent. Additionally, as was the case with the children in the current project, many of the participants in rate-building studies are unlikely to have been involved in fluency training previously. Thus, the performance requirements and instructional practices were new to them. As Binder (2004) suggested, a history of learning within a discrete trials format in which learners' response rates are controlled can reduce the likelihood that they will immediately adapt to self-paced procedures. Therefore, with increased familiarity with the procedures and expectations involved in rate-training, greater improvements may be revealed.

Future research should also investigate the effects of increasing response rates on the RESAA outcomes with larger populations. The results of the current studies have provided empirical evidence for the benefits of increased see/say phoneme rates for improving reading performance on the RESAA measures. Controlled studies of rate-building of other component skills in other academic areas are warranted.

Concluding statements

The current research project was a controlled, empirical demonstration of the effects of specific, incremental see/say phoneme rates on skill retention, endurance, stability, application and adduction. The controls for practice and reinforcement effects and the repeated probing of free-rate responses following both constrained-rate repeated practice trials and freer-rate practice allowed the positive findings of the research to be attributed to speed of responding, rather than to increased practice and reinforcement, regardless of the training method used to produce the response rates. Following, is a summary of the major findings of the research and the implications for practitioners and future researchers.

Summary of major findings

- With each student acting as his or her own control, a procedure in which accuracy and rate were trained simultaneously was more efficient in increasing see/say training rates than a stage process in which accuracy was trained to 100% before building rate for all of the Year 2 children.
- Training accuracy to 100% before building rate in a stage procedure was marginally more efficient in increasing see/say phoneme rates than training accuracy and rate simultaneously for five of the seven pre-primary children. For the two remaining pre-primary children, the simultaneous training procedure was slightly more efficient.

- Constrained-rate repeated practice trials produced increases in see/say phoneme rates but higher rates were generally achieved after self-paced practice for all children.
- Increases in see/say training rates produced concurrent increases in rates on measures of retention, endurance and stability for all of the children, and these rates often reached similar speeds as training rates in both Studies 1 and 2.
- Increases in see/say training rates produced concurrent increases in rates on the application probes for all of the Year 2 children in Study 1, for five of the seven pre-primary children in Study 1, and for all of the Year 2 children in Study 2.
- Concurrent increases in adduction rates were produced by increases in see/say training rates for all of the Year 2 children in Study 1, six of the seven pre-primary children in Study 1, and eleven of the twelve children in Study 2.
- A specific range of see/say training rates did not predict the same level of performance on each RESAA measure. Rather, retention, endurance and stability rates were generally higher than application and adduction rates at specific training rate aims. Application rates were also consistently higher than adduction rates at the same training rate aims.
- Children categorized as very poor, poor and average readers were able to build similar see/say rates over an equal training time period.
- For these children a specific range of see/say training rates did not predict the same level of performance on the RESAA measures for all participants. Of the three groups, the children categorized as very poor readers demonstrated the lowest RESAA rates and those categorized as average readers had the highest RESAA rates at similar training rates. The differences between the poor and

average groups' performance was far greater for the application and adduction probes than for the retention, endurance and stability probes.

- At around the 105-125 ppm and the 126-146 ppm rate aims, spontaneous and rapid increases in some RESAA rates, particularly application and adduction rates, were observed for some children.
- Higher see/say training rates produced a greater proportion of superior RESAA rates on the follow-up probes three months after the termination of the intervention for the Year 2 children in Study 1 (60%) and the children in Study 2 (76.5%).
- A one learning-channel cross (i.e., a hear/say task) produced greater evidence of adduction than a two learning-channel cross (i.e., a hear/mark task) in Study 1 but this finding was not supported in Study 2. Possible confounds due to the design of the adduction probes were discussed.
- Response rate measures were far more sensitive than percentage correct scores in differentiating levels of competency on the see/say phoneme sets and on the RESAA probes.
- The rate-building procedure was far more efficient in both studies in terms of the see/say rates attained and the increases in performance rates of the RESAA outcomes per practice repetitions, or opportunities to learn, and per reinforcer presentations.

<u>Implications for practitioners and future research</u>

- Building higher rates of component skills produced improved skill retention, endurance, stability, application and adduction for 96.6% of all of the RESAA tests conducted in each study in both conditions. Of the total 24 children involved in the research, 83.3% showed improvements in rates on all of the RESAA measures. Thus, overall, increased component see/say phoneme rates made the skill more functional for the learners.

- Freer-operant practice was a more efficient means of improving reading performance and achieving educational goals for students in schools compared to a controlled-rate repeated practice teaching format which, in itself, is also rarely found in contemporary classrooms.
- Rate measures were far more sensitive to differences in levels of competency both within and across individuals than percentage correct scores and allowed observation of the effects of additional practice beyond the 100% accuracy criterion. The use of rate measures of learning behaviour in classrooms would allow teachers to make more informed instructional decisions and maximise learning outcomes for students.
- Some children may need to build higher component rates than others for the skill to be of comparable function to individuals. The importance of collecting and analysing data for individual students and basing instructional decisions on these data trends is underscored.
- The spontaneous increases in some RESAA rates observed for some of the children at around the 105-125 ppm and the 126-146 ppm rate aims may imply a general, functional range of response rates that predict or optimize the occurrence of the RESAA outcomes. However, few children in the study attained the higher training rates and future research should investigate this trend with higher training rates than were attained in this research.

- Skill fluency can be determined by component rates that ensure the attainment of similar rates of component skill retention, endurance and stability. However, although evidence of composite skill performance on measures of application and adduction were produced by increased component skill rates, similar rates should not be expected on composite measures of application and adduction without explicit training.
- Evidence of application and adduction may imply learners are ready to advance to the next skill in a learning sequence. If learners encounter difficulty in increasing their rates on this skill, it is reasonable to assume fluency in one or more component skills was not reached, which would require learners to re-train the component skills to higher rates.
- The utility of learning channels for clearly defining and analysing the application and adduction outcomes was demonstrated. Practitioners and researchers need to agree on definitions of RESAA outcomes and their measurement to aid communication and allow better comparisons between studies. Further research using measures of adduction across one or more learning channels is required. Such research may provide implications for teaching through multiple learning channels to maximise learning outcomes.
- Loss in RESAA rates of component and composite performances over extended periods of no practice should be further explored. Research might investigate whether brief re-implementation of interventions would rapidly increase RESAA rates up to training rate levels even after periods of three to six months.